

Notes



Atomic Energy
Control Board

Commission de contrôle
de l'énergie atomique

INFORMATION BULLETIN 91-1

March 15, 1991

REGULATORY RESEARCH & SUPPORT PROGRAM FOR 1991/92 -- PROJECT DESCRIPTIONS

The Regulatory Research & Support Program (RSP) is intended to augment and extend the Atomic Energy Control Board's regulatory program beyond the capability of in-house resources. The overall objective of the research & support program is to produce pertinent and independent information that will assist the Board and its staff in making correct, timely and credible decisions on regulating nuclear facilities and materials.

The program is divided into nine main areas of research covering the safety of nuclear facilities, radioactive waste management, health physics, physical security, the development of regulatory processes, and special services. A total of 101 projects are planned for 1991/92, including a number which are ongoing from the previous fiscal year. Projects that are held in reserve in case funding becomes available are also listed. The spending estimates for the RSP were calculated on the basis of an expected budget of \$3.8 M. As of the date of issuance of this Bulletin, final budget for the RSP for 1991/92 had not yet been established, but it appears likely that it will be less than the amount originally anticipated.

Most of the projects will be carried out under contracts issued through the Department of Supply and Services.

This Information Bulletin contains a list of the projects with a brief description of each, and additional supporting information.

Additional copies of this Bulletin, or other information concerning its contents, may be obtained by contacting:

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EXPLANATION OF PROJECT DESCRIPTIONS

A. PROJECT NUMBER (unique to project)

- first digit number of the Mission Object (see main headings in "List of 1991/91 Projects", numbered from 2. Nuclear Reactors to 11. Special Services)
- second set of digits item number (beginning nominally with number 101) within the Mission Object
- third digit contract or phase number in a sequence of related contracts for a given item number (e.g., a full-scale study [2] following a feasibility study [1]). The number 1 appears even if a project is not subdivided into phases.

B. TITLE

C. SUMMARY

The three paragraphs state:

- WHAT is proposed or in progress and by what means
- WHY this project is proposed
- HOW it is intended to use the results.

The participation, if any, of other organizations is also mentioned.

D. PROPONENT

Originating division within the AECB, or other originator, of the proposal. (Abbreviations refer to AECB organizational units, whose full names are given under "Standard Abbreviations, AECB Organizational Units".)

E. TECHNICAL ADVISOR/EVALUATOR

AECB division (and individual staff member, where known) which gives advice to, or for liaison with, the Project Manager on certain technical aspects of the project. The evaluator assesses the quality of the work done by the contractor and also assesses how the results of the project may be used by the AECB, through a post-project evaluation.

F. PROJECT MANAGER

Name of staff member within the Research Divisions responsible for the project (to the extent that the AECB is committed, in the case of joint projects).

G. REVIEW PANEL

The Review Panel is a group of internal and external experts set up by the AECB to give advice to the Project Manager on some or all technical aspects of the project.

H. CONTRACTOR

For projects in progress, the name of the company or institution doing the work is given.

I. PRINCIPAL INVESTIGATOR

If known, the name of the principal investigator is given.

J. CATEGORY

0 - Projects in progress at the beginning of the program year (from preparation of work statement to acceptance of final report).

1 - Projects intended to be initiated in the program year.

2 - Projects which would be Category 1 but will not be initiated until other work is completed.

3 - Projects held in reserve in the event that funds become available in the program year.

K. FUNDING

<u>Past</u> <u>Years</u>	<u>Year Prior to</u> <u>Program Year</u>	<u>Program</u> <u>Year</u>	<u>Year after</u> <u>Program Year</u>	<u>Future</u> <u>Years</u>	<u>Project</u> <u>Total</u>
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- Actual expenditures are shown for past years.
- Estimated amount is shown for the program year; but this amount is subject to change. For items in Categories 2 and 3, the amount may be quite speculative.
- Amounts shown for years after the Program Year can be very speculative.

L. RELATED PROJECTS

Earlier directly-related projects are shown by project number along with the previous expenditures.

REGULATORY RESEARCH & SUPPORT PROGRAM 1991/92

2.101.1 Instrument Behaviour under Off-Normal Conditions

It is proposed to conduct a study on the behaviour, during and after selected hypothetical severe accident conditions, of instruments used in CANDU reactors. Emphasis would be placed on the accuracy of thermocouples, pressure transducers and flow meters during and after being forced to operate at the extremes of, or outside, their scales.

Information on instrument behaviour during and after severe accident conditions is scarce. This work, therefore, would generate new knowledge necessary to improve the understanding of instrument readings during and after abnormal events.

The results of this study would be used in assessing licensee assumptions and interpolations regarding accident scenarios described by instrument-reading records.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (A. Omar)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.102.1 Design, Analysis and Testing Tools for Real-Time Software

It is proposed to survey the latest developments in computer program design, analysis and testing tools, as applied to real-time critical systems. Then, based on the results of the survey, it is proposed to acquire a software tool to analyze the complexity and verification/validation test coverage aspects of safety-related software.

Due to the combination of the number of inputs and processing pathways, computer programs used to control nuclear reactor systems are difficult to verify and validate manually. The software industry is developing tools to assist software design, analysis and testing. These are sometimes called CASE tools.

The results of the survey phase would provide AECB staff with the latest information concerning what is available, enabling a knowledgeable assessment of the particular tools used by licensees to verify and validate their critical software. A software tool may also provide an effective means for AECB staff to rigorously and independently evaluate a particular system and the extent of test coverage proposed by the licensee.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$40k	\$0k	\$70k

Earlier Directly-Related Contracts and Funding:

2.105.2 Crack Propagation in Tough Ductile Materials - Carbon Steel

It is proposed to examine the results of carbon steel fracture toughness tests and pipe rupture experiments, and to formulate a theory describing the observed crack behaviour. In addition, it is proposed to evaluate whether the crack growth model which accounts for angled crack propagation is more or less conservative than the classical fracture mechanics approach.

Recent testing performed in the IPIRG program (see project 2.111.1) has shown that crack growth in carbon steel piping material is not across the plane of principal stress, but runs at a sharp angle (approximately 45°) to it. However, current pipe rupture analysis, using linear-elastic or elastic-plastic fracture mechanics, assume that cracks propagate circumferentially to produce a plane-ended guillotine break. These analyses are used in licensing submissions for defect disposition and to demonstrate leak-before-break behaviour. The proposed project would address this discrepancy between the theory and actual crack growth behaviour.

The results would serve as a technical basis for defect dispositioning and other crack stability assessment work and would be used in the assessment of licensing proposals in this area.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$25k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.105.1	\$99,000
2.111.1	\$399,000

2.111.1 International Piping Integrity Research Group

It is proposed to continue membership in the International Piping Integrity Research Group (IPIRG). This group, organized by the U.S. Nuclear Regulatory Commission (USNRC), is examining the fracture behaviour of large piping systems. The proposed program by the USNRC includes: fracture tests done on approximately 60 large-diameter pipes, of which about one third are directly relevant to CANDU; material tests to establish a data base for fracture analysis; assessment of the efficacy of fracture calculations; review of degraded piping; and review of the state-of-the-art analytical and experimental developments. The cost of Canadian participation in the IPIRG program would be shared equally between AECB and Ontario Hydro (each contributing \$300k US).

There is a need to develop and verify the technology to justify: using analytical assessments to disposition piping defects and prescribe inspection frequencies for them; permitting leak-before-break concepts in lieu of mechanical protection for hypothetical pipe ruptures; and current procedures for response to primary heat transport system leaks.

The results would be used to support, or change, the licensing criteria for protection against pipe rupture, to define in-service inspection frequencies, and to develop rules for reactor shutdown after leaks have been detected.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	USNRC/Battelle
Principal Investigator	M. Mayfield
Category	0

Past	90/91	91/92	92/93	Future	Total
\$387k	\$7k	\$5k	\$0k	\$0k	\$399k

Earlier Directly-Related Contracts and Funding:

2.111.2 International Piping Integrity Research Group - 2

It is proposed to participate in Phase II of the International Piping Integrity Research Program (IPIRG-2) after the completion of Phase I (IPIRG-1) by mid 1990. In IPIRG-2, data will be obtained for both quasi-static and dynamic (seismic) loadings, and experiments will be conducted on piping configurations representative of actual piping systems. The new program will also include selected special-effect experiments in support of the pipe system experiments. The USNRC will be the lead organization, with multi-national contributions to the program. The cost of Canadian participation is expected to be shared equally between the AECB and Ontario Hydro (each contributing \$360K over 4 years).

The current IPIRG program (IPIRG-1) will be completed by July 1990. The work which will be conducted in the new program (IPIRG-2) will build on the solid base of information that has been established in IPIRG-1. The new program will include testing of piping systems, including cracks in straight pipes, elbows and tees. Such information is crucial to assessing licensees' designs.

The information generated by this project would be used in assessing new design concepts such as leak-before-break, defining in-service inspection frequency, and evaluating licensing criteria for protection against pipe rupture.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	USNRC/Battelle
Principal Investigator	M. Mayfield
Category	2

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$110k	\$110k	\$110k	\$330k

Earlier Directly-Related Contracts and Funding:

2.105.1	\$99,000
2.111.1	\$399,000

2.117.3 International Standards for Safety Critical Software

It is proposed to provide independent expert review of current worldwide developments in standards for safety critical software. This will assist AECB staff in preparing regulatory requirements for the documentation and verification of safety critical software for CANDU power reactor applications.

During the development of the trip computer software for the Darlington NGS, difficulties were encountered in specifying software requirements and documenting the design and implementation so that safety aspects could be reviewed. After great effort by the licensee and AECB staff, an interim version of the software was accepted for use until a new version which fully addressed the reviewability concerns could be completed. Regulatory guidelines are required to formally communicate the AECB's needs for reviewable safety critical software. The development of these guidelines was begun under previous projects 2.117.1 and 2.117.2 with Professor David Parnas and Dr. Wolfgang Ehrenberger. In order to finalize the regulatory guidelines and to ensure that they are reasonable in the light of other international standards, it is important to have Dr. Ehrenberger's continued involvement with this project.

This project will help AECB staff to produce an effective and practical set of regulatory guidelines for safety critical software which take into account international standards and experience.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	Gesellschaft fur Reaktorsicherheit (GRS)
Principal Investigator	Dr. W. Ehrenberger
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$25k	\$10k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.117.1	\$25,000
2.117.2	\$25,000

2.118.1 Behaviour of the Calandria Structure under Severe Conditions

It is proposed to conduct an analytical study to investigate the survivability of the calandria structure under a hypothetical rapid increase in the temperature and pressure of the moderator.

It is uncertain how the calandria structure would eventually fail when subjected to a rapid increase in the temperature and pressure of the moderator. If the upper portion of the calandria (i.e. the reactivity mechanism deck) were to fail first this would result, in certain CANDU designs, in a breach of containment. Information is needed, therefore, to determine the consequences of such a hypothetical situation and then, if necessary, the measures which would be required to prevent or mitigate its consequences.

The results of this project would expand the knowledge base of AECB staff and augment their understanding of the behaviour of a CANDU reactor under a combination of hypothetical human errors and systems responses.

Proponent	CQAD, SED					
Technical Advisor/Evaluator	CQAD (B. Jarman), SED (L.D. Macdonald)					
Project Manager	A. Omar					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$60k	\$30k	\$0k	\$90k	

Earlier Directly-Related Contracts and Funding:

2.126.2 Critical Channel Power Uncertainty Measurement

A project is proposed to verify the statistical correctness of the uncertainty assessment of the critical channel power (CCP) submitted by the licensees in support of the new CANDU-6 reactor overpower (ROP) trip setpoints.

Previous work done by the Statistical Consulting Centre of Carleton University has indicated that previous CCP assessments lacked in statistical rigor. Since the AECB does not currently have in-house expertise to verify the correctness of the newly proposed procedure, the need for the proposed work is self evident.

The outcome of this project would allow the AECB staff to make sound judgement in relation to the current submission, and would afford guidelines on how to perform such work by the AECB in the future.

Proponent	SED					
Technical Advisor/Evaluator	SED (C. Snoek)					
Project Manager	D.J. Martin					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k	

Earlier Directly-Related Contracts and Funding:

2.126.1 \$18,000

2.127.5 Statistically Valid Random Testing for Real-Time Software

It is proposed to develop a procedure for using statistical testing to evaluate the probability that a critical real-time software system (such as the proposed shutdown systems for Darlington Nuclear Generating Station) meet its requirements. This project is an elaboration of the preliminary recommendations made in projects 2.127.2 and 2.127.4 concerning statistical testing.

For safety-critical systems it is essential that an estimate of the upper bound of the probability of failure be determined before the system is placed in service. By applying N statistically valid, randomly selected test cases, we can determine the likelihood that a system with a probability of failure greater than a certain value would successfully pass the N tests. Then by selecting an acceptable upper bound for the probability of failure, the number of test cases required, N, can be derived and applied resulting in a tangible numeric estimate of the trustworthiness of the system.

The results of this work will assist AECB staff in preparing recommendations for regulatory actions concerning the trip computer software for the Darlington shutdown systems.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor, L. Tougas)
Project Manager	D.J. Martin
Review Panel	
Contractor	Carleton University
Principal Investigator	Dr. S. Mills
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$33k	\$19k	\$0k	\$0k	\$52k

Earlier Directly-Related Contracts and Funding:

2.127.1	\$31,000
2.127.2	\$72,000
2.127.3	\$50,000
2.127.4	\$8,000
2.127.6	\$90,000
2.127.7	\$110,000
2.127.8	\$100,000
2.127.9	\$50,000

2.130.2 Self-Testing of Programmable Controllers and Microcomputers

It is proposed to initiate a two phase project to develop guidelines for the review of self-test software in programmable controllers and microcomputers used in safety related and special safety systems for CANDU nuclear power stations. Phase 1 would review current and proposed equipment and similar commercial products, along with the particular electronic technologies applied to identify the possible hardware failure modes, and to develop a description of the faults to be detected by an adequate self-test program. Phase 2 would describe in detail methods to detect the hardware failure modes identified in Phase 1, would develop a comprehensive checklist and set of guidelines for self-tests that are independent of the particular electronic technology used, and would, as an illustrative example, evaluate the systems reviewed in Phase 1 using these guidelines.

The use of programmable controllers and industrial microcomputers is extensive in CANDU nuclear power stations, both in new stations and in the retrofitting of older units. This technology involves a complex blend of real-time software and high performance microcircuit devices for which the reliability history is limited. Guidelines are required to allow the AECB staff to evaluate the adequacy of the self-test software with respect to fault detection and its contribution to overall reliability. It is important to recognize that if complex software is used to check reliable hardware, the system reliability may actually be decreased.

The results of this project would assist AECB staff in the assessment of the self-test methods used in the shutdown systems at Darlington NGS and in the OH-180 Programmable Controllers used throughout Darlington's safety related control systems.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Tougas, R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$70k	\$0k	\$0k	\$70k

Earlier Directly-Related Contracts and Funding:

2.130.1 \$7,000

2.148.2 Molten Fuel/Moderator Interaction - Feasibility of Large Scale Tests

It is proposed to conduct a program of large scale experiments to investigate the potential for, and consequences of, steam explosion arising from the interaction between molten fuel and moderator. The experimental set-up would be extensively instrumented (including provision for high speed optical and x-ray photography). This work may be done as contribution in kind into the USNRC Severe Accident Research Program (Project 2.120.1) which has a budget for short-term and long-term research of \$58M.

Previous AECB research projects (Projects 84.1.30, 2.120.1 and 2.148.1) on this topic have indicated that the potential for steam explosion due to molten fuel/moderator interaction after a severe fuel channel flow blockage cannot be ruled out. The AECB has just completed a small research program involving small scale experiments to provide basic understanding of the steam explosion phenomena. In the long term, large scale experiments will be required to develop an appropriate analytical tool to predict the occurrence and consequences of steam explosion.

The findings of this project would provide information that would be used to determine the extent, cost and potential difficulties and/or merits of conducting the large scale tests. In addition, by contributing the results of this work to the USNRC SARP, the AECB would gain a benefit equivalent to 200 times the money spent on this project.

Proponent	SED
Technical Advisor/Evaluator	SED (V.Q. Tang, C.W. Snoek), PRDA (J. Detorakis)
Project Manager	A. Omar
Review Panel	
Contractor	McGill University
Principal Investigator	D. Frost
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$150k	\$100k	\$400k	\$650k

Earlier Directly-Related Contracts and Funding:

84.1.30	\$55,380
2.120.1	\$50,000
2.148.1	\$36,000

2.152.4 Five-Channel-per-Pass CATHENA Code for Darlington NGS

It proposed to modify the input data package for the AECB version of the CATHENA code from the current single-channel per pass to a more detailed five-channel per pass. The input data will be set up in accordance with Darlington NGS design data although a more detailed representation of the reactor, particularly in the region where boiling is expected to occur, is envisaged for this version. In developing the five-channel-per-pass version, emphasis will be placed on two-phase separation phenomena, e.g., flow separation in the reactor headers with possible flow recirculation between the feeders via the headers (without going through the steam generator).

The information on which Darlington NGS safety submissions are based is produced by licensee codes such as SOPHT (and, in the future, TUF), which contain numerous physical models and assumptions. There is a need to have an independent AECB in-house computing capability to perform check runs of the models and assumptions as part of the AECB normal course of evaluating the licensee calculations.

The new version of CATHENA will be used by AECB staff to analyze various accident scenarios. These results will be compared with those produced by the licensee's computer codes.

Proponent	SED
Technical Advisor/Evaluator	SED (K. Amrud)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$0k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

86.1.22	\$16,441
2.152.1	\$30,000
2.152.2	\$45,000
2.152.3	\$30,000

2.153.1 Computer Codes for Examining Circulation within Containment

It is proposed to acquire the computer code COBRA-NC and convert it to work on one of the AECB computers. The code would be used to examine events such as LOCA and LOECC specifically to determine post-event hydrogen distribution within containment.

In safety analyses for LOCA and LOECC, the concentration of the hydrogen released inside the containment is assumed to be uniform. This assumption needs to be confirmed particularly when cooling fans are not credited. Hydrogen concentration distribution within the containment is an important parameter in taking the decision as to whether the ignitors should be initiated.

The outcome of this study would be used in evaluating the consequences of a hydrogen burn, and the appropriateness of the locations of the hydrogen ignitors within the containment.

Proponent	SED
Technical Advisor/Evaluator	SED (J.W. Blyth)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$0k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

2.155.1 Maintenance: Means and Methods

It is proposed to conduct a critical survey of the literature dealing with the methods, procedures and techniques of maintenance used to ensure the adequacy and to determine the status of equipment and components performance while in service. The study would cover nuclear and non-nuclear industries. The proposed survey would include detailed descriptions of various maintenance techniques such as preventive, corrective and reliability-centred maintenance.

According to independent assessments by the utilities and the AECB, inadequate maintenance is the primary cause of numerous significant events. A project that would critically review the current maintenance practices is proposed. Such a project would assist in establishing an understanding of the terminology used in Canadian utilities and those of other countries and in highlighting the differences in the basic understanding and use of the different means of maintenance.

The results would improve and enhance AECB staff understanding of the means and methods used for maintenance.

Proponent	RSDA, CQAD, PRDB					
Technical Advisor/Evaluator	CQAD (D. Vincent), PRDA&B (G. Schwarz, H. Ragheb), RSDA (Omar)					
Project Manager	A. Omar					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k	

Earlier Directly-Related Contracts and Funding:

2.157.1 Consequences of Severe Accidents in Canadian Power Reactors

It is proposed to continue the study of the consequences of postulated severe accidents at Canadian nuclear generating stations (NGS). "Severe accidents" are accidents which are more severe than the so-called "design-basis accidents" which currently form the basis for AECB licensing of nuclear power reactors. The first phase of the study is based on the Pickering A, Pickering B and Darlington nuclear generating stations. The severe accidents to be studied initially include the current menu of single and dual failures not involving containment impairment, combined with various modes of containment failure, including modes not currently considered in licensing. Where data are supported by some degree of validation, analyses are done on a "best estimate" basis; that is, by selecting the best estimate of, or most likely values for, parameters influencing the consequences, or by selecting a range of values for parameters which are known to vary considerably, e.g., weather conditions. The study would include both the short term and long term consequences and local, regional and global impacts. Subsequent phases of the study would include detailed considerations of specific event sequences. The panel will continue its function until this project is completed and during the preparatory discussions necessary to establish the requirements for subsequent phases.

The study is proposed because of increased public skepticism about the industry claims regarding the low probability of severe accidents in the wake of the Three Mile Island and Chernobyl accidents. On the other hand experience from the Three Mile Island accident, which is probably more relevant to Canadian reactors than the Chernobyl accident, demonstrated that existing safety analyses may be unduly pessimistic in predicting consequences.

The information obtained from this study would be useful to the AECB and to governments for developing advice or making decisions regarding nuclear insurance or siting policy for large power reactors.

Proponent	RSDA, DAA, DRR					
Technical Advisor/Evaluator	DRR (Z. Domaratzki), DAA (J.G. Waddington), RPD (M. Measur					
Project Manager	A. Omar					
Review Panel	14					
Contractor	Atlantic Nuclear Services Ltd.					
Principal Investigator						
Category	0					
Past	90/91	91/92	92/93	Future	Total	
\$150k	\$45k	\$12k	\$0k	\$0k	\$207k	

Earlier Directly-Related Contracts and Funding:

2.157.2 Detailed Analysis of Severe Accident Consequences

It is proposed to perform detailed analysis of the consequences of selected event sequences at Pickering or Darlington nuclear generating stations. The work would consider the work done in a screening study (project 2.157.1) being conducted for the AECB. The scope of the proposed detailed analysis would cover: a) estimation of fission product release from, and retention within, fuel, heat transport systems, moderator and containment; b) determination of dose levels for specific weather conditions, population density and distribution, and dose and time thresholds; and c) estimation of the direct and indirect, immediate and long-term, health and socioeconomic effects. Among the analytical methods and computer codes which would be used in the proposed study would be those which would have been recommended in project 2.157.1. Considerable discussions would be required to establish the objectives and scope of, and tasks to be performed in, this project.

The cost of a severe accident is not only associated with the loss of generated power and health effects, but also includes costs related to liability, cleanup, litigation, transboundary contamination, and long-term health, social, economic and psychological effects. Two of the major costs of the Three Mile Island accident are related to the increase in the liability coverage (current proposal before the courts is at \$750 million) and to the decrease in public acceptance of the nuclear energy option. As for the Chernobyl accident, the major costs are those related to the cleanup, the long-term health and psychological effects, and a global collective dose of 600,000 person-sieverts.

The knowledge which will be gained from this study would be useful to the AECB and the provincial and federal governments in developing advice and making decisions related to liability, siting policies and emergency plans for large power reactors.

Proponent	DAA, RPD, RSDA
Technical Advisor/Evaluator	DAA (J.G. Waddington), RPD (M. Measures), RSDA (A. Omar)
Project Manager	A. Omar
Review Panel	14
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$65k	\$150k	\$300k	\$515k

Earlier Directly-Related Contracts and Funding:

2.157.1 \$240,000

2.170.1 Reliability of Electrical Motors under Accident Conditions

It is proposed to determine the functional capability of naturally aged safety system electrical motor windings under accident and post-accident conditions, and to correlate the findings with the results of various non-destructive diagnostic measurements performed before and after the accident exposure. A heavy water coolant recovery motor was removed from NPD NGS containment area for this purpose. The proposed work would involve collection of data on the nature of the service environment, and laboratory tests and assessments at Ontario Hydro Research Division (OHRD).

Reliability of safety system electrical motors under expected accident and post-accident conditions is essential for the effective mitigation of accidents, should they occur. Present non-destructive diagnostic techniques have a limited capability for detecting the degradation of motor windings before failure and for predicting the remaining life for normal operating conditions. (Research work at OHRD sponsored by EPRI is addressing this limitation.) These diagnostic techniques are not able, as yet, to predict the performance of motor windings under accident and post-accident conditions.

The proposed work would enhance the development of effective condition monitoring techniques capable of detecting degradation before failure and of predicting remaining life under all anticipated service conditions, including accident and post-accident conditions. The results would improve the capability to assess the findings of diagnostic motor tests and would thus contribute to maintaining operational readiness of nuclear power plant safety systems.

Proponent	SED
Technical Advisor/Evaluator	SED (T. Leung)
Project Manager	A. Omar
Review Panel	
Contractor	Ontario Hydro, Research Division
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$100k	\$0k	\$0k	\$100k

Earlier Directly-Related Contracts and Funding:

2.174.2 Hydrogen Absorption-Desorption at Metal Surfaces - Phase 2

A project is proposed in which experiments would be carried out to demonstrate that oxides of zirconium may react with deuterium to form D₂O. This demonstration will involve the use of isotopically labelled oxygen (oxygen-18) to prepare zirconium specimens, before exposing them to gaseous deuterium, then monitoring the molecular mass of the reaction products.

This project will supplement experimental work carried out in FY 1989/90 in project 2.174.1, in which a mechanism for breakdown of the protective oxides in CANDU pressure tubes was investigated. The previous work gave evidence that when oxidized zirconium specimens were heated in the presence of deuterium, reactions took place which produced D₂O. However, the experiments did not show conclusively that it was oxygen from the zirconium specimens, rather than from other sources, which participated in these reactions. The proposed experiments using isotopically-labelled oxygen will resolve this criticism and will demonstrate the existence of the postulated mechanism.

The results of this work will be made available to industry, as an indication of a possible line of enquiry into the oxide breakdown observed in CANDU pressure tubes.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I.M. Grant)
Project Manager	A. Omar
Review Panel	
Contractor	University of Toronto
Principal Investigator	Dr. C. Ward
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$0k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

2.174.1 \$70,000

2.175.1 Pump Cavitation and Piping Vibration (I)

It is proposed to conduct a multi-phase study to investigate pump cavitation and piping vibration, and their interrelationship. Phase I would review Ontario Hydro pump stability piping analyses, and perform a literature search on large amplitude piping vibrations. Also in Phase I the contractor would be asked to design a simplified small diameter pipe loop. This should take into account the predicted primary heat transport system piping vibration and main coolant pump two-phase flow characteristics. Phase II of the study would be to build and commission a test loop. The instrumentation should be sufficient to define the displacement of the test section, the flow characteristics of the fluid, and the overall energy balance. The test results would be analyzed and compared with the findings of Phase I.

Pump cavitation under voided conditions can cause severe pipe vibration. Calculations, based on forces measured directly on reactor main coolant pumps, predict that the vibration can be of such magnitude that failure of the pump supports or piping can occur. These calculations are complex and include numerous assumptions so that it is difficult to assess whether they are conservative or not.

The results of this study would be used by AECB staff to acquire information on the characteristics of cavitation-induced piping vibration and its relationship to the energy input to the pump. This information would then be used in the evaluation of piping stability analyses presented by licensees.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$150k	\$25k	\$235k

Earlier Directly-Related Contracts and Funding:

34-2-5-1	\$16,000
34-2-5-6	\$14,000

2.177.2 Fuel Channel Refilling - Phase II

It is proposed to review in detail the capabilities and limitations of the CATHENA code in simulating fuel channel refilling and rewetting phenomena, and recommend improvements, if necessary, to the numerical scheme and correlations.

In a current AECB research project (2.177.1) fuel channel refilling data are being reviewed, and a few experimental cases are being analyzed using the "as-is" CATHENA code. There is a need to extend the scope of the current project to review the CATHENA code capabilities and limitations in predicting the behaviour of a fuel channel refilling and rewetting under accident conditions. Accurate prediction of such behaviour is critical in predicting the fuel temperature which, in turn, influences the prediction of the fission product releases.

The findings of this project will provide AECB staff with further knowledge regarding two-fluid codes. It is anticipated that such codes will be used in licensing submissions in the very near future.

Proponent	SED
Technical Advisor/Evaluator	SED (V.Q. Tang)
Project Manager	A. Omar
Review Panel	
Contractor	BCS Thermal Science Inc.
Principal Investigator	Dr. M. Shoukri
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$35k	\$16k	\$0k	\$0k	\$51k

Earlier Directly-Related Contracts and Funding:

2.177.1 \$35,920

2.179.1 Performance of Steam Generator Emergency Water Injection

It is proposed to conduct an experimental study in which a section of the secondary side of a steam generator would be built to investigate phenomena associated with the emergency injection of water into the steam generator secondary side under accident conditions. The test section would be as close as possible in design to the actual geometry of the steam generators used in the Darlington NGS.

Licensing submissions addressing the effectiveness of the steam generator emergency cooling injection system have treated some of the crucial parameters as uncoupled. AECB staff believe that combined effects such as spray header water distribution, hot wall, and steam flow behaviour would dictate the overall performance of the steam generator emergency cooling system.

The results of this study should provide insight on particular aspects of cold water injection into the steam generator secondary side, and would be used to assess the validity of licensee submissions on this topic.

Proponent	SED					
Technical Advisor/Evaluator	SED (H. Tezel), POD (C. Wang)					
Project Manager	A. Omar					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$95k	\$0k	\$0k	\$95k	

Earlier Directly-Related Contracts and Funding:

2.181.2 A Computer Program for Assisting Emergency Response Function

It is proposed to fund a contract to have a user-friendly computer program written and set up on the AECB computer system to be used for simulation of nuclear emergency response in relation to public radiation exposure control.

Currently, AECB has limited capability in nuclear emergency response. Experience from the recent involvement with Nuclear Emergency Preparedness Exercise at Bruce A suggested that problems still exist with OH's Emergency Response Preparedness and there are not enough timely resources for helping with the decision-making for public radiation exposure control.

The results of the project, a computer program, will be used for simulation and independent assessment of nuclear plant and surrounding conditions following a postulated accident as an input to response decisions.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Truong), RPD (R.E. Irwin), PCS (T. Diamantstein)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$0k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

2.181.1 \$20,000

2.184.3 Ballooning of CANDU Pressure Tubes - Experimental Studies

It is proposed to conduct small-scale separate effects tests on as-received, irradiated, and hydrided pressure tube specimens to verify the hypotheses formed from previous phases of this project: a) that uniform hydriding has no effect on ballooning; and b) that irradiation and hydride blisters will affect ballooning. The influence of the ambient environment on pressure tube ballooning will also be assessed in these tests. The experiments would be designed and conducted in accordance with the findings of a current project (2.184.2) that is anticipated to be completed by the end of FY 1990/91.

Safety analyses predicted that certain failures in reactor cooling systems could lead to coolant stagnation in fuel channels and to the ballooning and eventual rupture of pressure tubes. Current models of pressure tube ballooning behaviour are based on tests conducted with new pressure tube material in an inert environment, and may overestimate the ductility and creep behaviour of end-of-service-life pressure tubes under actual conditions.

The results of this project would lead to an improved ability to predict the strain at failure of rapidly straining pressure tubes by confirming or developing hypotheses about the effects of irradiation and deuteriding of zirconium alloys. This would permit improved assessments by AECB staff of predictions of pressure tube behaviour in accident conditions.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I.M. Grant), SED (L.D. Macdonald)
Project Manager	A. Omar
Review Panel	15
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$100k	\$20k	\$0k	\$120k

Earlier Directly-Related Contracts and Funding:

2.184.1	\$35,000
2.184.2	\$42,000

2.187.2 Operational Readiness of Filtered Air Discharge Systems - Phase 2

It is proposed to review and evaluate the impact of the Pickering NGS Filtered Air Discharge (FAD) system re-design on the work previously carried out under project 2.187.1. In addition, it is proposed to review the proposed changes in the Post-LOCA Radiation Monitoring System (PLRMS) at Pickering NGS.

The review of the Pickering FAD System under project 2.187.1 was based on an old design, since the information on the redesign was not available at that time. Also, during the review, it was identified that the PLRMS is one of the systems that could play a crucial role in decisions on FAD system operating modes and timing, and on emergency response planning, and could, therefore, affect FAD system effectiveness.

Results of the proposed work would be used as a technical basis for assessments of the adequacy of the testing and maintenance methods used in Canadian nuclear power plants.

Proponent	PRDA, SED, RPD					
Technical Advisor/Evaluator	PRDA (U. Nurmsuo), SED (L. Truong), RPD (S.H. Ching)					
Project Manager	Q.S. Truong					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$15k	\$0k	\$0k	\$15k	

Earlier Directly-Related Contracts and Funding:

2.187.1 \$50,000

2.190.1 Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments

As Phase 1 of a systematic nuclear reactor plant aging program, it is proposed to prepare structured lists of CANDU nuclear power plant safety-significant components of a) CANDU nuclear power plants and b) Canadian research reactors which are susceptible to aging degradation (the term "components" is used in a broad sense, meaning plant components, systems and structures.) The lists will be determined on the basis of CANDU and research reactor operating experience, expert knowledge, information from equipment qualification and other relevant external programs. Their structure would indicate priority according to which preliminary aging assessments would be conducted for the selected components in the scoping phase (Phase 2) of the program.

Aging degradation of NPP and research reactor components has the potential to adversely affect plant safety if it is not effectively managed. Nuclear reactor plants have thousands of components which experience aging effects to a greater or lesser degree. Because of limited resources, it is necessary to select and rank these components for which comprehensive evaluations of the impact of aging on plant safety should be conducted and effective aging management strategies and methods developed.

The results of this project would provide input for the scoping phase (Phase 2) of the nuclear reactor plant aging research program which constitutes the second step in the selection of plant components for the comprehensive aging assessments to be done in Phase 3 of the program. The program is designed with the intent to a) generate knowledge to identify and resolve emerging and unanticipated problems as they arise, and b) provide technical bases for licensing assessments and decisions relating to fitness for service of plant components and to operational safety of nuclear plants throughout their entire service life.

Proponent	RSDA				
Technical Advisor/Evaluator	PRDA (G. Schwarz), PRDB (E.J. Dunstan), SCD (P. French), CQ (K. Pereira)				
Project Manager	A. Omar				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$20k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

2.192.1 Effect of Sheath Strain on Critical Heat Flux

It is proposed to investigate experimentally the effect of fuel sheath strain on critical heat flux (CHF). The work would involve the construction of a three-metre long, uniformly- heated bundle consisting of three elements (trefoil); the upstream half would have the nominal dimension of the 37-element CANDU fuel. The heater elements in the downstream half would be three percent larger in diameter. Critical heat flux experiments would then be conducted for both geometries (nominal and three percent larger) by reversing the flow direction. (Uniform heating implies that dryout would occur at the end of the channel and this would simplify the instrumentation.)

The Pickering Unit 1 fuel failure in November 1988 led Ontario Hydro and Chalk River Nuclear Laboratories to conduct detailed examinations of both failed and intact fuel. Results have shown that the intact fuel elements were strained by as much as two percent. However, the effect of fuel sheath strain on CHF has not been experimentally investigated. Although subchannel analysis can provide some information, experimental confirmation is required.

Experimental data on the relative reduction in CHF for strained fuel elements as compared to nominal fuel would assist AECB staff in estimating the reduction in the safety margins for CANDU stations containing strained fuel. Based on these results AECB staff could decide whether it is necessary to request the licensees to conduct similar tests with full-scale fuel channels.

Proponent	SED				
Technical Advisor/Evaluator	SED (C. Snoek)				
Project Manager	A. Omar				
Review Panel					
Contractor					
Principal Investigator					
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$13k	\$75k	\$0k	\$0k	\$88k

Earlier Directly-Related Contracts and Funding:

2.193.1 Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants

It is proposed to study the phenomena relating to: a) hydrogen combustion in multiple jets (parallel and radially interacting) of hydrogen-steam mixtures; and b) the effect of radiation on the burning characteristics of hydrogen, e.g., flame velocity, transition to detonation, and detonation characteristics.

The above studies are proposed for the following reasons. a) In nuclear reactor containment, jets of hydrogen-air-steam mixtures are discharged through the openings in the air conditioning unit ducting at various locations inside the containment. These jets may be in the form of parallel jets (e.g. at the top of the feeder cabinet) or radially interacting (e.g. at the bottom of the steam generator or the heat transport pump). Jet interaction may create intense turbulence resulting in a very fast deflagration or deflagration-detonation transition. This may result in higher than predicted peak pressure in the vault or a local pressure pulse which may threaten the containment seals around the steam generator or the pump penetrations. This is intended to be a scoping study to determine experimentally the key parameters which may have a significant effect on the combustion processes (e.g. flame velocity, deflagration to detonation transition and the propagation of detonation), and to provide some quantitative measure of these effects. b) Radiation fields may result in significant amounts of free radicals which have the potential to affect combustion characteristics. This is intended to be an experimental scoping study to examine any significant effect that the free radicals (in composition and concentrations that may exist in the calandria cover gas space) may have on the combustion process.

The results of the work will enable AECB staff to assess the validity of the consequences predicted by the licensee of a hydrogen burn inside the CANDU containment and in the calandria.

Proponent	SED					
Technical Advisor/Evaluator	SED (J.W. Blyth)					
Project Manager	A. Omar					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$50k	\$25k	\$0k	\$75k	

Earlier Directly-Related Contracts and Funding:

2.197.1 Fission Product Release at SLOWPOKE Reactors

It is proposed to obtain and analyse fission product release data for the reactor container water and gas headspace of the HEU SLOWPOKE-2 reactors to determine the condition of the present high enriched uranium cores. This work includes the development of the gamma ray spectrometry measuring system, the measurement of fission product releases in one or more SLOWPOKE-2 reactors, and the analysis of the data. The analysis will include a literature search for previous experience with uranium alloy fuel. Emphasis will also be placed on the development of a model to describe the phenomenon involved, the release behaviour of the fission products, and their subsequent transport in the heat transport system.

The SLOWPOKE-2 facility has a radiation monitor just above the pool water. After several years of operation, the three oldest facilities have found that the radiation level may increase above the alarm setpoint during prolonged operation at high power. The reason for the increased level of radioactivity has been identified as an increase in the concentration of fission products in the container water. While this does not present a major hazard, the fact is that this change is unexpected and unexplained. Therefore, investigation of the matter is required.

The proposed work would provide information about SLOWPOKE fuel performance, which will be used to assess safety and licensing options for these reactors.

Proponent	SCD
Technical Advisor/Evaluator	SCD (C. Morin), SED (L.D. Macdonald)
Project Manager	Q.S. Truong
Review Panel	
Contractor	Royal Military College
Principal Investigator	B.J. Lewis
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$15k	\$35k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.198.1 Containment Performance under Severe Accidents

It is proposed to co-sponsor a research program which is being initiated to generate a database on concrete cracking, crack closure, leaking flows, and fission products attenuation. The lead organizations for this project are AECL, the University of Alberta, and Sandia National Laboratory. Participation will be solicited from other organizations.

The performance of containment concrete under severe accident conditions is the subject of recent research activities involving experiments and computer calculations. The results of Sandia's one-sixth scale containment test indicated that reclosure of cracks might prove to be an important factor in mitigating the consequences of accidents. Also, special effects experiments (AECB projects 84.1.1 and 2.147.1) indicate that the permeability of concrete to fission products is affected by the type of permeant (gas, liquid, aerosol, or mixtures), its size and chemical composition, and the fact that internal cracks in the concrete provide an easy leak path for the permeant. There is a need to confirm such observations in large-scale experiments in which typical reactor conditions and fission product chemicals would be used.

The information generated in this multi-national project would be used by AECB staff to assess the performance of concrete under severe accidents and under some high temperature transients.

Proponent	RSDA, SED
Technical Advisor/Evaluator	RSDA (A. Omar), SED (K. Asmis, J. Blyth), PRDA (F. Rinfret)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$100k	\$100K	\$50K	\$250k

Earlier Directly-Related Contracts and Funding:

2.199.1 The Prevention, Mitigation and Accommodation of Water Hammer

It is proposed to join the Water Hammer Prevention Project which is being undertaken by the Electric Power Research Institute (EPRI). A database for water hammer will be compiled using field and experimental data and subjected to root cause analysis; an engineering reference manual will be produced. Also, models and computer codes that deal with the issues will be reviewed. From plant experience, guidelines to prevent, diagnose and assess water hammer will be produced. The AECB and Ontario Hydro would jointly represent Canada's interests in the program. The AECB share would be via an in-kind contribution by performing high-pressure experiments in Canada and feeding the results into the database of the program.

In a previous AECB contract (Project 2.146.1) a critical review was conducted of information on loadings arising from injecting cold water into a two-phase system. Water hammer was recognized to be the main mechanism causing such loadings. One of the recommendations that came from this project was to consider joining the EPRI program, since it is the most comprehensive work currently being undertaken by a research organization. In addition, there is a need to obtain information on water hammer in high pressure, steam-water systems relevant to CANDU heat transport systems.

The project will produce diagnostic tools with which AECB staff would be able to examine the cause and the consequences of events involving water hammer in single- and two-phase systems.

Proponent	CQAD, RSDA, SED
Technical Advisor/Evaluator	CQAD (J.K. Pereira), RSDA (A. Omar), SED (J. Blyth), POD (C. Wang)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$80k	\$0k	\$120k

Earlier Directly-Related Contracts and Funding:

2.146.1 \$24,000

2.200.1 A Safety Course for Pressure-Tube Type Reactors

It is proposed to develop an annual course which would provide a suitable forum for exposing AECB staff and other national and international nuclear industry personnel to the most recent developments in safety analysis, operation and regulation of pressure-tube type reactors. The proposed project would involve design, development and initial implementation of such a course. The course would be given by experts drawn from the nuclear industry and academic institutions and could be prepared and presented in conjunction with them.

Currently in Canada, there does not exist an appropriate and formally structured program which provides an opportunity for staff of the AECB and Canadian and foreign utilities to focus on current trends in safety analysis, operation and regulation of pressure-tube type reactors.

A custom-made course for participants interested in pressure-tube type reactors would be more effective than similar courses on light water reactors. The course would be used to upgrade the skills of the attendees by providing state-of-the-art information on a wide range of topics related to the design, safety analysis and regulatory aspects of pressure-tube type reactors. The course would also serve to introduce new personnel into the realm of nuclear safety analysis and evaluation.

Proponent	DAA, RSDA					
Technical Advisor/Evaluator	DAA (J.G. Waddington), RSDA (A. Omar), TC (J. Didyk)					
Project Manager	A. Omar					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$60k	\$30k	\$0k	\$90k	

Earlier Directly-Related Contracts and Funding:

2.202.1 Severe Accident Source Term

It is proposed to develop a software package suitable for desktop computers to estimate the order-of-magnitude value of source terms within containment. The software would have the capability to estimate fission product species and their concentrations in grains, grain boundaries, free inventory, heat transport systems, and containment. The software would have flexible input suitable for introducing accident conditions as well as the conditions within the containment.

In a current project (Project 2.157.1) being conducted for the AECB, a methodology is being developed and used to provide order-of-magnitude estimates of the source term for a severe accident. It would be extremely useful if this methodology were put in a user-friendly software package which could be used by AECB staff to obtain an indication of the behaviour of fission products after an accident.

The software which would be the product of this project would be used by AECB staff in performing sensitivity studies of various factors influencing the prediction of fission product concentrations in an accident. A potential subsequent project would be to develop software to estimate the fission products released from the containment. These estimates could be fed to a dispersion software package (e.g., ALOHA) to estimate the dose after a specific scenario. Ultimately, this suite of software would be used as input to the estimation of the health and socio-economic effects of an accident, and in plans for emergency preparedness.

Proponent	RSDA, SED				
Technical Advisor/Evaluator	RSDA (A. Omar), SED (V.Q. Tang, L. Truong, L.D. Macdonald)				
Project Manager	A. Omar				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$65k	\$20k	\$0k	\$85k

Earlier Directly-Related Contracts and Funding:

2.203.1 Intermediate and Full Scale Tests on Hydrogen Burn Phenomena

It is proposed to enter into a cooperative program, under an agreement with CANDU Owners Group (COG), conducted by KfK and Battelle (Europe) to investigate hydrogen behaviour in containment. The proposed program would include performing experiments in intermediate and full scale, multi-compartment facilities to investigate the effect on hydrogen combustion of equipment size, gaseous mixture composition, multi-compartment configuration and the effects of the presence of steam. In addition, the effect of hydrogen combustion on the redistribution of aerosols and the effectiveness of the catalytic ignitor/recombination unit will also be studied.

Current licensee submissions are based on results produced from small-scale and special effects experiments. There is no information on hydrogen combustion behaviour in a large-scale multi-compartment arrangement similar to those normally found in the containment of a nuclear power reactor. Furthermore, information on the scaling laws, flame acceleration due to obstacles, and combustion in interacting jets is also very limited. In a previous study conducted for the AECB (Project 2.138.1) it was recognized that key assumptions related to hydrogen mixing and burning rate could not be justified. In addition to conducting in-situ tests to determine the hydrogen distribution in the Darlington NGS containment, research in some of the above areas was also recommended.

The results of this project would be used to assess the assumptions in licensee submissions. The knowledge gained in this project would also provide AECB staff with insight into the combustion phenomena and some basis for assessing the effectiveness, claimed by licensees, of the mitigation of the consequences of a hydrogen burn.

Proponent	SED
Technical Advisor/Evaluator	SED (J.W. Blyth)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$7k	\$7k	\$7k	\$21k

Earlier Directly-Related Contracts and Funding:

2.204.1 Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings

It is proposed to reactivate a project (which was proposed in FY 1984/85 but postponed) to investigate the consequences of pressure tube failure on in-core components. The proposal for Phase I deals with the construction and then the use of a test facility to characterize, in a series of separate-effect tests, the thermalhydraulic loadings within a closed tank due to a single fuel channel rupture at operating conditions.

The original proposal of 1984/85 was postponed due to the initiation at that time of a Japanese program addressing the characteristics of pressure tube rupture in a closed tank in which the test facility was vertical. On the basis of recent information currently obtained, AECB staff believes that because of differences in geometry and operating conditions the Japanese tests are not relevant to the issues raised by AECB staff in BMD 85-158. Based on current calculations and experimental results, AECB staff are satisfied that the calandria shell is not at risk; but are not fully satisfied that the consequences on the in-core safety-related components would not hinder the safe shut-down of the reactor. The reasons for this position are given in BMD 85-158.

The findings of this phase of the program will provide information on the degree and extent of the thermalhydraulic loadings within the closed tank.

Proponent	SED, CQAD, RSDA
Technical Advisor/Evaluator	SED (C.W. Snoek, J. Tong), CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$400k	\$300k	\$750k

Earlier Directly-Related Contracts and Funding:

84.1.10 \$82,140

2.205.1 Training Requirements for Authorized Operating Personnel

It is proposed to conduct a review of utility and AECB training requirements of authorized operating personnel at CANDU nuclear power plants. The work would be done in three phases. The first phase would consist of a review of the relevant information currently available to the AECB. The second phase would involve reviewing the training currently being delivered at the utilities in relation to the documented requirements. The final phase would involve comparisons and evaluation of the collected information and would include recommendations for appropriate regulatory training requirements.

The AECB is presently considering extending the current operator authorization process so that periodic re-authorization could be mandatory for continuation in the authorized position. For this purpose, we are assessing the training requirements of the authorized staff to achieve and maintain required levels of competence.

The proposed work would provide information for developing appropriate regulatory training requirements in the authorized positions.

Proponent	OCD					
Technical Advisor/Evaluator	OCD (G. Turcotte), SED (L. Innes)					
Project Manager	D.J. Martin					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$60k	\$0k	\$0k	\$60k	

Earlier Directly-Related Contracts and Funding:

2.206.1 Methodology for Assessment of Training Programs

It is proposed to document methods and techniques which can be used in performing a systematic assessment of the quality and effectiveness of training programs for nuclear plant personnel. The proposed work would involve a survey of programs used for quality control of training in those industries which have an impact on public safety. It would also include a review and evaluation of the findings and specific recommendations for an effective assessment tool for AECB use.

The current AECB audit program is intended to confirm the adequacy of training received by the operating personnel through a formal examination process. To extend this process and ultimately to reduce reliance on examinations, AECB staff are planning to conduct periodic assessments of the quality and effectiveness of the utilities' training programs.

The proposed work would provide guidelines to the AECB staff for conducting assessments of the quality and effectiveness of the utilities' training programs.

Proponent	OCD					
Technical Advisor/Evaluator	OCD (G. Turcotte)					
Project Manager	D.J. Martin					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$100k	\$0k	\$0k	\$100k	

Earlier Directly-Related Contracts and Funding:

2.208.1 Review of Darlington Probabilistic Safety Evaluation Events Involving Operating Action

It is proposed to conduct a review of the Darlington Probabilistic Safety Evaluation Study to identify those accidents where operator action or omission can significantly increase the severity of the consequences.

The test items in the AECB authorization examinations are based upon current operating and training documents. However, there is a need to evaluate completeness of failure modes and scenarios currently included in the examinations.

The proposed work would identify events which would be appropriate as base material for developing questions for AECB examinations and simulator testing scenarios.

Proponent	OCD				
Technical Advisor/Evaluator	OCD (G. Turcotte), SED (L. Innes)				
Project Manager	D.J. Martin				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$120k	\$0k	\$0k	\$120k

Earlier Directly-Related Contracts and Funding:

2.210.1 Participation in the USNRC Severe Accident Research Program

It is proposed to participate in kind in the United States Nuclear Regulatory Commission (USNRC) Severe Accident Research Program (SARP); the estimated cost of the SARP is \$14.5 million U.S. AECB would participate in kind by conducting its own research (e.g., project 2.148.2) and make the results of such research available to all participants. The estimated cost shown below is, therefore, only to cover cost associated with attending the participants' meetings which are held every six months.

The USNRC SARP is a comprehensive research program designed to resolve issues related to severe accidents such as, in the near-term, containment performance, and in the long-term, phenomena exhibited by severe accidents and methods for assessing fission products behaviour. The information generated from this program will provide a pool of knowledge from which the AECB would extract relevant work and use it as is, or after being modified, for CANDU applications.

The information which would be gained from this project would be used by AECB staff in the performance of projects related to severe accidents assessment.

Proponent	DAA, RSDA
Technical Advisor/Evaluator	DAA (J.G. Waddington), RSDA (A. Omar)
Project Manager	A. Omar
Review Panel	
Contractor	USNRC
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$180k	\$180k	\$180k	\$540k

Earlier Directly-Related Contracts and Funding:

2.211.1 Tritium Surface Contact Dosimetry

It is proposed to measure the uptake of tritium by mammals (rats, pigs, and humans) following contact of skin with surfaces which are contaminated with elemental tritium (HT), and to study quantitatively the subsequent distribution of organically-bound tritium (OBT) and oxidized HT (HTO) in body tissues and fluids.

An unknown fraction of the total dose from tritium arises from contact with surfaces contaminated with tritium. The only human data on tritium uptake from contact with surfaces contaminated with elemental tritium have been acquired from a few experiments that followed four volunteers in 1965. More recently, work at CRNL has been done with rats, using HT-contaminated planchettes. The present study is proposed because the earlier work on exposures of humans and rats, via contact with tritium-contaminated surfaces, has produced as-yet unexplained and sometimes dissimilar findings. These findings call into question the accuracy of currently-used calculational techniques for evaluating the dose to nuclear power reactor workers, and others, who are occupationally exposed to tritium via contact with surfaces contaminated with tritium (e.g., among workers at tritium removal facilities and tritium lighting manufacturers, and among university researchers).

It is anticipated that the findings of this project will enable AECB staff and licensees to evaluate more accurately the dose and its distribution within the bodies of workers who are subject to exposure to tritium-contaminated surfaces. (It is expected that different aspects of the work will be carried out in Canada, in the United States, and in France. The AECB will be a member of a management group responsible for directing the work. Two external review groups, one of technical experts and the other concerned with ethical aspects, will be constituted to advise the management team. The work is proposed to be cost-shared among Ontario Hydro, Canadian Fusion Fuels Technology Project (CFFTP), Atomic Energy of Canada Ltd., and AECB. Ontario Hydro has proposed to fund more than 50% of the cost of the total project, the upper estimate of which is likely to be approximately \$800k. The estimated AECB funding, presented below, is based on this upper estimate.

Proponent	RPD					
Technical Advisor/Evaluator	RPD (F. Horvath)					
Project Manager	E. Rabin					
Review Panel						
Contractor	Ontario Hydro, Research Division					
Principal Investigator						
Category	0					
	Past	90/91	91/92	92/93	Future	Total
	\$1k	\$50k	\$50k	\$50k	\$0k	\$151k

Earlier Directly-Related Contracts and Funding:

2.213.1 Review of Human Factors Guidelines

It is proposed to fund a contract which would provide, through examination of the relevant literature, an annotated bibliography of current human factors standards, criteria and methodology applicable to the design, operation and maintenance of nuclear power plants. The bibliography should be prepared as annotated lists divided according to specific application areas within the plant (e.g. main control room displays, maintenance activities).

The AECB should provide guidance on the application of human factors to the design, operation and maintenance of nuclear power plants. Current information and references will be incorporated into the standards to be established in regulatory guides.

The contract would provide information which would aid development of AECB standards that should be met by licensees in the application of human factors knowledge to design, operation and maintenance of nuclear power plants.

Proponent	SED				
Technical Advisor/Evaluator	SED (L. Innes)				
Project Manager	D.J. Martin				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$0k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

2.216.1 Validation of Positive Void Effect

It is proposed to fund a contract which would examine the positive void reactivity effect in CANDU reactors. The study would include a detailed and critical literature search and review of the experimental and theoretical justification for the currently-used values of the void reactivity of the primary heat transport system.

Simulations of reactor power pulses under distorted flux conditions have indicated a proximity to prompt criticality. The AECB, therefore, requires to confirm present estimates of the positive void coefficient. In response to the AECB's requirements (Chernobyl Report), Ontario Hydro has conducted an investigation of the effects of distorted flux/power shapes on shut off rod effectiveness. In Pickering A, the distorted shapes arising from low moderator levels sufficiently reduce the effectiveness of the shut off rods to the extent that prompt criticality is predicted to occur. In addition, the CANDU-3 reactor design is characterized by uni-directional flows in the reactor core. This feature results in a significantly larger void reactivity effect. It is, therefore, important to obtain upper-bound estimates of the void reactivity resulting from a complete blowdown of CANDU reactors.

The results of the contract would provide information which will be used in the safety analyses regarding the potential of prompt criticality to occur in power reactors in some postulated accidents.

Proponent	SED
Technical Advisor/Evaluator	SED (P. Akhtar)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$25k	\$25k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.217.1 Seismic Monitoring East and North of Toronto

This project, which commenced last year with a background noise survey and a selection of potential sites for instrumentation, is continuing. Based upon recommendations of the panel hired for this study, it is proposed to run both digital and analogue seismographs, and to extend the project from three to five years.

This study was proposed in order to undertake seismic monitoring in the western Lake Ontario-Lake Simcoe-Georgian Bay area. This area was chosen because of the existence, there, of the Pickering and Darlington Nuclear Generating Stations. The objective of the study is to locate, as precisely as possible, microseismic events and ultimately to determine whether or not there is a spatial relationship between earthquakes, irrespective of size, and variously expressed lineaments in the aforementioned area.

It is anticipated that the results of this study will bear directly on improving seismic hazard estimates because reliable locations of micro-seismic events will aid geoscientists in determining whether or not there are active faults in the vicinity of the generating stations at Darlington and Pickering. If it is shown that there are active faults, then seismologists will be able to effect calculations of seismic wave attenuations from particular locations rather than assuming random sources.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	22
Contractor	Seismic Geophysical
Principal Investigator	A. Mohajer
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$128k	\$100k	\$135k	\$0k	\$363k

Earlier Directly-Related Contracts and Funding:

2.219.2 Validation Methods for Probabilistic Safety Assessments - Phase 2

It is proposed to fund a contract to continue the work of Project 2.219.1, "Validation Methods for Probabilistic Safety Assessments". The phase 2 work would provide a detailed review methodology for probabilistic safety assessments submitted to the AECB. It is anticipated that this project would prototype the use of the proposed methodology against sections of the Darlington probabilistic safety evaluation.

To date, the AECB has not yet reached a consensus on the role of probabilistic safety assessments in the licensing process; a comprehensive validation process is an important step in that direction.

The results of this work would be used in the continuing review of probabilistic safety assessments; the results of this work may also influence the way future probabilistic safety assessments are produced to make the review and validation task more effective.

Proponent	SED
Technical Advisor/Evaluator	SED (G.J.K. Asmis)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.219.1	\$50,000
2.219.2	\$22,000
2.219.3	\$46,000

2.220.1 Impact of Expert Systems

The primary objectives are to explore any current development activities in expert systems for use in operations within the nuclear industry. Especially, the development of decision support systems for control room operator use will be assessed with respect to practicality and probability of implementation.

The rate of the developments in the field of expert systems increases the probability of their implementation in NPP operations. A preliminary study is required to assess the probability of practical implementations in the near future, and to provide initial guidance on the likelihood of practical implementation.

The results of this preliminary study will indicate whether further investigations should be conducted to assess probable operational, human and organizational consequences.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Innes)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$10k	\$0k	\$0k	\$10k

Earlier Directly-Related Contracts and Funding:

2.221.1 Evaluation of Boiler Chemical Cleaning Techniques

It is proposed to evaluate the current techniques available for cleaning of boilers. Emphasis will be placed on chemical techniques, such as those envisaged for the boilers at Bruce A Nuclear Power Station.

The reason for proposing this project is to acquire the knowledge which will allow AECB staff to keep up-to-date on the advantages and disadvantages of various cleaning techniques. This work will determine if boiler performance could be restored and identify any potential problems resulting from such cleaning operations which could adversely affect the system heat removal capacity or the safety of the workers, the public, and the environment.

It is anticipated that the results of this work will provide to AECB staff the necessary information to make informed licensing decisions.

Proponent	PRDB				
Technical Advisor/Evaluator	PRDB (D. Tennant), CQAD (I.M. Grant)				
Project Manager	Q.S. Truong				
Review Panel					
Contractor					
Principal Investigator					
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$20k	\$30k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.222.1 Marine Geophysics in Lake Ontario

It is proposed to undertake a marine geophysical investigation in Lake Ontario. The survey is to include seismic penetration deep into the bedrock, echo-sounding, shallow seismic penetration into the lake bottom sediments and bedrock surface, side-scan sonar and magnetics. It is hoped that participation of other agencies such as the Atlantic Geosciences Centre can be arranged in order to share costs. The planned funding for this project is based on an assumption that costs will be shared, with AECB funding data analysis only.

This work is proposed to determine whether major geophysically expressed lineaments within the immediate vicinity of the Darlington and Pickering nuclear generating stations are potentially seismically active. Information on their characteristics, as well as their implications in conjunction with other geoscientific indicators, are presented in AECB INFO-0342. A single echo sounding traverse, conducted in June 1990, across one of the lineaments (NPLZ) in Frenchman's Bay, showed a change in elevation of the lake bottom.

It is anticipated that this study will indicate whether the lineaments have, or do not have, topographic expression in the unconsolidated sediments on the bottom of the lake. If there is topographic expression, particularly abrupt, this will be an indication that the potential for seismic activity may be high. If such is the case, an analysis will be needed of the length of, and the vertical elevations across, the topographically expressed segments to estimate the magnitude of previous earthquake activity.

Proponent	RSDA					
Technical Advisor/Evaluator	RSDA (J.L. Wallach)					
Project Manager	J.L. Wallach					
Review Panel	22					
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$65k	\$0k	\$0k	\$65k	

Earlier Directly-Related Contracts and Funding:

2.217.1 \$373,000

2.223.1 Use of VDM in Formal Specifications

It is proposed to evaluate and compare the specification language "VDM" with the formal specification techniques advocated by Dr. David Parnas. This project would be to: a) produce a VDM specification for a prototype system (the Monitoring and Shutdown System described in A. John Van Schouwen's thesis); b) to develop an animation of that specification; and c) to develop a test plan which can be used to test the animation.

VDM is currently the most widely known modern formal software specification and development technique. It has been and is used in some industrial applications and is taught and researched in Universities throughout Europe. VDM and other languages such as 'Z' and 'HOL' are the preferred formal techniques applied by computer scientists and mathematicians. The AECB, through its research program, is developing and promoting a different formal documentation and analysis technique, on the basis that the Parnas A-7 model better fits the real-time control engineering environment of the safety systems that we must license. Before we adopt the Parnas technique it is prudent to explore these other formal methods: if the techniques are comparable in terms of applicability and verifiability, then it may be appropriate to recommend the use of VDM and take advantage of the large amount of research already done, or to investigate how to combine ideas from both techniques.

The results of this study will be useful as a comparison with the techniques which were used for the specification of the Darlington shutdown systems – the part which caused the most difficulty during the review. This study will increase our awareness of the international scene in safety critical software development and may point out areas where current Canadian practice could be improved.

Proponent	SED					
Technical Advisor/Evaluator	SED (R. Taylor)					
Project Manager	Q.S. Truong					
Review Panel						
Contractor	Rolls-Royce and Associates Limited					
Principal Investigator						
Category	0					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$25k	\$15k	\$0k	\$0k	\$40k	

Earlier Directly-Related Contracts and Funding:

2.224.1 Emissivity of Zirconium Alloy Surfaces

It is proposed to gather and critically review values for the emissivities of Zircaloy-4 and Zirconium - 2.5% weight Niobium. The project would focus on determining the effect on emissivity of the oxide layer stoichiometry, thickness, phase transition, texture and uniformity, surface temperature, and impurity contamination from the fuel, and wavelength.

Heat transfer at high temperatures is credited for lowering the fuel temperature by radiation to the pressure tube. This is affected by the emissivity of the surface. Very little data has been submitted for the conditions of application.

Improved knowledge of high temperature heat transfer would assist in determining what the maximum fuel temperature would be under high temperature transient conditions.

Proponent	SED
Technical Advisor/Evaluator	SED (L.D. Macdonald)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.225.1 Estimates of Fission Product Grain-Boundary Release

It is proposed to conduct a study to compare the lower-bound fission product grain-boundary release inventory inferred from spike releases observed in transient annealing experiments with predictions from the computer code ELESIM.

Current estimates of grain-boundary inventory for release of fission products during such times as rewetting are based on models that have been validated only for total release. Recent annealing experiments have shown large spike releases at the start of the anneal indicating that grain-boundary inventories might be much greater than estimates produced by current models. This may be attributed to the possibility that high temperature diffusion coefficients have either not been measured or their accuracy is relatively poor.

Knowledge of fission product grain-boundary inventory will assist in determining source terms during rewetting and periods of thermal and mechanical shocks resulting from depressurization.

Proponent	SED
Technical Advisor/Evaluator	SED (L.D. Macdonald)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.226.1 Graphical Post Processor for Scientific Computer Codes

It is proposed to develop a generalized graphical post processor for scientific computer codes. Given geometrical specifications and simulation results from computer codes such as CATHENA, TUF and PATRIC, the processor will schematically present the network being analyzed and graphically code/shade the variation of a specified property around the network. The development of this package should be done on a UNIX (Apollo) system to enhance portability and conform with the current AECB trend. A graphics library such as CA-DISSPLA may have to be acquired to simplify the development of this post processor.

The outputs from complex scientific computer codes tend to be cumbersome and difficult to quickly interpret. Development of the proposed software package may eliminate this problem.

The AECB staff would be able to use this software package to present graphically the result of computer codes, and analyze them in a quick fashion. This facility should expedite the analysis review procedure involving computer code outputs. In addition, the acquisition of a graphic library such as CA-DISSPLA could be utilized for other applications, such as CANDU-3, by the AECB staff.

Proponent	SED
Technical Advisor/Evaluator	SED (K. Amrud)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

2.227.1 Failure Rate of Piping in Hydrogen Sulfide Systems

A project is proposed in which failure data for process piping in hydrogen sulfide service would be gathered and critically reviewed, with the purpose of estimating piping failure rates. Use will be made of national and international pools of data relating to the nuclear, petrochemical, and other industries.

Plants supplying heavy water for CANDU reactors utilize hydrogen sulfide as a process medium. Gaseous hydrogen sulfide is toxic at low concentrations in air. Therefore, one of the potential hazards arising from heavy water plant operation is the possibility of releasing, due for example to a piping failure, hydrogen sulfide to the environment. In addition, hydrogen sulfide imposes severe corrosive service conditions on the materials of construction. To confirm data supplied by licensees, independent estimates of piping failure rates under similar or related service conditions are sought.

The estimates of failure rates produced in this project would be used in verifying risk assessment models employed for heavy water plants.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I. Grant)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.228.1 Acceptance Limit for Steam Generator Tube Loss of Wall Thickness

A project is proposed to perform an assessment of acceptance limit used for continued service of steam generator tubes degraded by fretting. The subject plant would be Bruce B nuclear generating station. After having reviewed available inspection records for Bruce B steam generator tubes, the contractor would advise on: a) potential failure mechanisms (including continued fretting, fatigue, environmentally-induced cracking, and overload under design basis conditions); b) criteria for removal of tubes from service; and c) potential limits on the extent of plugging.

Fretting wear, due to flow-induced vibration, is occurring at the U-bend supports in Bruce B steam generators. As a result, many tubes have suffered loss of thickness at the supports up to 60% in some cases. Based on burst pressure, an acceptance limit has been proposed which theoretically permits wall thickness loss of up to 88%. In view of the potential consequences of simultaneous failure of several tubes, assurance is sought that such an acceptance limit would be conservative for long-term operation.

An independent assessment of steam generator tube degradation at Bruce B NGS would assist AECB staff to determine whether the current acceptance limit for wall thickness loss is conservative. The extensive experience with steam generator tube degradation in the United States would be an invaluable source of information for this project.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I. Grant)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$20k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

2.229.1 Criteria and Tools for Scientific Software Quality Measurements

Not all software used in the nuclear industry needs the rigorous formal verification and reliability testing which are being used on safety critical software. This project is to survey accepted software quality criteria and available tools for measuring software quality, to make recommendations as to the most appropriate criteria and tools for the AECB to use in the evaluation of scientific codes, and to apply these recommended criteria and tools to a specific example.

Currently, the AECB focuses most of the review of scientific modelling software on the mathematical models and their representation of physical reality. However, it has been recognized that the transformation of the mathematical models into software can introduce errors. A method of evaluating the quality of the software is needed. Since this software tends to be large and complex, it is unlikely that manual review techniques would be feasible; automated tools should be investigated. It may also be useful to investigate methods of partitioning and classifying the software so that critical parts can be examined in more detail.

This project will provide AECB staff with a better understanding of the area of software quality measurement and should provide recommendations and a worked example of specific tools and techniques which can be used in practice.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.230.1 Testing for Software Reliability in Computer Systems

This project will build upon the trajectory testing already carried out on safety critical software systems. This research work will have two goals: a) to determine the attributes of a computer system and its external input sequences which will allow statistically valid random testing to be done to specified confidence levels; and b) to explore techniques for obtaining statistically valid reliability figures for existing computer systems.

Experience with critical software systems in aerospace and telecommunication applications indicates that the software contribution to system reliability could be significant. Software reliability is different from hardware reliability because all failures are the result of design errors – software does not "wear out", and an error in one copy of the software will exist in all other copies. Previous and current projects (e.g. 2.127.5) have investigated the current state of the art in software reliability estimation. This project will extend that work by finding specific techniques to make software more amenable to reliability testing and by finding test strategies for software systems which cannot be completely reinitialized on a regular basis.

The results of this study would assist AECB staff in evaluating the reliability of reactor shutdown systems and control systems, when such systems include software.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$40k	\$0k	\$75k

Earlier Directly-Related Contracts and Funding:

2.127.5	\$52,000
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2.231.1 Functional Block Languages and Design Methods

This project is to investigate functional block languages and techniques for use in safety-related systems, especially in distributed control systems.

The preliminary design of the CANDU 3 nuclear generating station has proposed the use of a distributed control system which would be programmed using a functional block language. This is a significant departure from a central control system programmed more traditionally in languages such as FORTRAN or Assembler. Functional block languages are supposed to be easier for control engineers to understand and use. The AECB needs assurance that these gains are not offset by any decrease in safety.

This project will provide AECB staff with better understanding of functional block languages, how they are used in distributed control systems and what safety issues arise in their use.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$40k	\$0k	\$75k

Earlier Directly-Related Contracts and Funding:

2.232.1 Object Oriented Languages and Design Methods

This project is to investigate the potential of object-oriented languages and design methods for real-time safety-critical applications and for simulation software used for nuclear generating station design and evaluation.

Object-oriented techniques are currently having a widespread impact on the software industry. These techniques incorporate the ideas of information hiding modules, simplified and controlled module interfaces, abstract data types, hierarchies of objects with inherited characteristics, and message passing interfaces. Some of these ideas show promise in the areas of software verification, reusability of modules and programmer productivity.

The results of this project will provide AECB staff with the background needed to evaluate the use of object-oriented languages and design methods in safety-critical and simulation systems for nuclear generating stations.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.233.1 A Cumulative Knowledge Base for Software Testing

This project is to investigate the possibility of developing a more realistic test environment for CANDU software. This would be comprised of a "knowledge base" forming an abbreviated description of the characteristics of a CANDU nuclear generating station especially its behaviour during upsets or accidents.

Our concern is that the random testing done on software systems will not subject the systems to the most demanding conditions which are likely to be encountered following an upset or accident. In particular, we feel that the sequences of plant conditions surrounding an accident are not being realistically simulated during system testing. The information needed to improve these simulations would come from experiences with real significant events and from "intelligent" conjecture and simulations. Currently, this information is held in the experience of plant engineers and gets lost as people leave the organization or are transferred to new positions. This project would examine the feasibility of capturing this experience in a "knowledge base" which would be continually updated and which would be used to improve the quality of software system testing.

The results of this project could eventually lead to the development of a useful tool for capturing important information about the operation of CANDU plants and for use in software system testing.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$15k	\$35k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.234.1 Review of "Sub-Tier" Software Standards

It is proposed to have an independent review of Ontario Hydro's sub-tier software development standards. This independent review will provide input to a decision as to whether to accept these standards for the development of a prototype system and the redesign of the Darlington Safety Shutdown Systems.

Ontario Hydro has proposed to define and submit to the AECB detailed standards for the development of safety critical software. This should fulfil part of the requirements placed on Ontario Hydro by AECB's licensing decision for Darlington No. 13/90. Considering the importance of these standards in the redesign of the Darlington Shutdown Systems, and all future software-based safety systems, it is important to thoroughly review Ontario Hydro's submissions in the light of accepted high-level standards (see 2.127.10), other national and international standards and best current software development practices.

This project will provide AECB staff with independent and expert advice on the acceptability of Ontario Hydro's detailed software standards.

Proponent	SED				
Technical Advisor/Evaluator	SED (R. Taylor)				
Project Manager	Q.S. Truong				
Review Panel					
Contractor					
Principal Investigator					
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$30k	\$10k	\$0k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

2.127.10 \$40,000

2.234.2 Evaluation of Tools and Methods for the Development of Safety Critical Software

It is proposed to investigate the current state of the art in tools and methods for developing and verifying safety critical software and to evaluate Ontario Hydro's tools and methods.

As part of their plan for standards and redesign of the Darlington Shutdown System software, Ontario Hydro will be selecting and/or developing tools and methods. Many tools and methods are currently available, but it is not certain whether they are suitable for the kind of formal specification and verification being planned. It is important for the AECB to be kept abreast of developments in this area so that we can properly assess the use of these tools and methods and understand outputs which may be submitted by licensees.

This project will provide AECB staff with information on what tools are currently available, their characteristics and relative merits plus a comparison with Ontario Hydro's selected tools and methods for the development of the trip computer software and the application of the accepted software development standards.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	\$40,000
2.235.1	\$40,000

2.234.3 Review of Prototype Application of Software Standards

It is proposed to have an independent review of Ontario Hydro's submissions regarding the prototype application of their software standards. This review will evaluate the complexity and relevance of the selected prototype application, suggest procedures and techniques of reviewing software design and documentation against accepted standards, demonstrate these procedures and techniques on the prototype application, and evaluate Ontario Hydro's interpretation and application of the standards.

Ontario Hydro has proposed that a prototype application be developed as a test of the standards before applying them to a real safety shutdown system. The AECB should make use of this opportunity to develop and practice review and evaluation techniques.

This project will provide AECB staff with valuable insight and examples of how to evaluate Ontario Hydro submissions for software developed according to their new standards.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$25k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	\$40,000
2.234.1	\$40,000
2.234.2	\$50,000

2.234.4 Review of Trip Computer System Specifications

It is proposed to have an independent review of system requirement specification documents for the Darlington shutdown systems (SDS1 and SDS2) to help determine whether the systems have been completely and correctly specified in light of the accepted standards and best current specification techniques.

The first step in the redesign of the Darlington shutdown systems will be a revision of the system requirement specifications. It is recognized that the existing specifications are too ambiguous and inconsistent to provide a strong foundation for the redesign. Consequently, it is expected that Ontario Hydro will submit a new system requirement specification which will have to be reviewed for completeness, correctness, conformance to standards and safety.

This project will provide AECB staff with independent and expert advice concerning the acceptability of the system requirement specification.

Proponent	SED					
Technical Advisor/Evaluator	SED (R. Taylor)					
Project Manager	Q.S. Truong					
Review Panel						
Contractor						
Principal Investigator						
Category	2					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$0k	\$50k	\$0k	\$50k	

Earlier Directly-Related Contracts and Funding:

2.127.10	\$40,000
2.234.1	\$40,000
2.234.2	\$50,000
2.234.3	\$50,000

2.234.5 Review of Trip Computer Redesign

It is proposed to have an independent review of Ontario Hydro's submissions regarding the redesign of the Darlington NGS shutdown systems (SDS1 and SDS2) to determine whether the documents properly follow the accepted standards and to determine the safety, maintainability and verifiability of the design.

Considering the special conditions related to the shutdown systems software in the Darlington Operating License 13/90, it is extremely important that the redesigned software be reviewed thoroughly and fairly. For this reason, it is essential that independent software expertise be brought into the review process. The current intent is to completely review the higher level documentation (Requirement Specifications and Preliminary Design) and to conduct a guided inspection/walkthrough/audit of selected parts of the detailed design and code.

This project will enhance the quality and credibility of AECB's review of the redesigned Darlington shutdown system software.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$0k	\$0k	\$100k	\$100k

Earlier Directly-Related Contracts and Funding:

2.127.10	\$40,000
2.234.1	\$40,000
2.234.2	\$50,000
2.234.3	\$50,000
2.234.4	\$50,000

2.234.6 Review of Trip Computer Testing

It is proposed to have an independent review of:

1. the new design of the shutdown systems to determine if statistically valid random testing is feasible within an acceptable time period,
2. Ontario Hydro submissions regarding deterministic testing, and
3. Ontario Hydro submissions regarding random testing.

The testing of the redesigned shutdown systems is an important component of assuring their safety and reliability. The AECB has stated that safety system software must be designed for testability and verifiability, and that both deterministic and random testing must be done.

This project will provide AECB staff with independent and expert advice on the design quality and the acceptability of Ontario Hydro's test reports.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$0k	\$0k	\$50k	\$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	\$40,000
2.234.1	\$40,000
2.234.2	\$50,000
2.234.3	\$50,000
2.234.4	\$50,000
2.234.5	\$100,000

2.235.1 Processes in Radioactivity Removal

In order to gain knowledge on the state of the art in engineered processes in radioactivity removal prior to releases from nuclear power plants, it is proposed to review critically these processes, including those using filters with media other than charcoal (e.g. silver zeolite, stainless steel, sand, etc.), or other processes such as photochemical and venturi scrubbing techniques.

Technical and procedural problems involving the use of charcoal filters in the Emergency Filtered Air Discharge systems have been studied in a previous research project (2.187.1). During this study, it has become evident that a comparative review of alternative methods would assist Board staff in assessing radioactivity removal techniques.

The results of this work will provide the Board's staff the necessary knowledge to make informed licensing decisions.

Proponent	SED					
Technical Advisor/Evaluator	SED (L. Truong), PRDB (J. Ricard), PRDA (U. Nurmsoo), RPD (S.H. Ching, R.E. Irwin)					
Project Manager	Q.S. Truong					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k	

Earlier Directly-Related Contracts and Funding:

2.187.1 \$50,000

2.236.1 Diagnostic Skills and Mental Model Development

It is proposed to fund a literature review to produce a review report for the AECB on the extent to which systematic procedures can be applied to aid in the formation of mental models for use in supervisory control in process industries, and in the use of these models for system diagnosis in nuclear power plants.

During plant events that are beyond the design basis, operators are required to diagnose the problem, and to make decisions on corrective actions. These cognitive activities are thought to be aided by the operator's mental model of the ideal plant, compared to his model of the upset plant. An understanding of how far these models can be shaped through intentional strategies would make a significant contribution to safe plant operation.

Safe and effective plant control through control room operator performance may depend more on diagnosis than on compensation and recovery activities. Although the relative importance of these activities is debated, they clearly are linked, and are both involved in most operator tasks. The development of appropriate regulatory positions will be aided through achieving a better understanding of the individual differences in diagnostic processes, and reducing the degree of variability in them.

Proponent	SED				
Technical Advisor/Evaluator	SED (L. Innes), OCD (R. Thomas)				
Project Manager	D.J. Martin				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

2.237.1 Assessment of Psychological Capacities Requirements

It is proposed to fund a project which would review the professional training and psychological literature on needs analysis for continuing knowledge and skills development commensurate with advancement through a technical career. The report would detail findings with relevance to operator continuing training and operator requalification needs in the nuclear industry.

Individual operator competence levels and competence requirements are established for entry level positions at each grade of the operator family. The development of these skills and the acquisition of new skills and abilities with progression through a career is not well defined. It is a pre-requisite to the relicensing of mature operators that it is known what skills and abilities they must have to function effectively in their role. This is not known presently in sufficient clarity to allow suitable regulation development.

Continuing high levels of operator performance on the job throughout a career is a vital component of nuclear power plant safety. The maintenance of these performance levels depends in large measure on the development by operators of appropriate new knowledge and skills as they progress through increasing responsibility levels. Regulatory review to establish that operators are being equipped properly to do the job is a requirement of mature operator re-licensing.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Innes), OCD (R. Thomas)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

2.238.1 Review of Computer Codes MODTURC and PHOENICS

It is proposed to fund a contract to review the computer codes MODTURC and PHOENICS in order to ensure that their mathematical formulation of the physical phenomena, numerical representation and the solution are valid. These reviews would also include an examination of the available information on the verification and validation of the codes. In addition, a sensitivity analysis study to demonstrate the effect of important parameters in each of these codes and a code-to-code comparison for a given problem(s) would be required.

MODTURC and PHOENICS are complex three dimensional codes which have been used to simulate the behaviour of the moderator system inside the calandria in the safety analyses submitted by Ontario Hydro and NB Power respectively. The results of these codes help define the moderator temperature control set-point (taking into account the minimum available subcooling margin) in order to ensure that the moderator remains an effective heat sink under accident conditions. In view of staff limitations in the Computer Code Review Group, it is felt that the services of a competent consultant would be highly desirable.

A timely review of these codes will help AECB staff gain confidence in the capability of these codes to predict moderator system behaviour under normal as well as accident conditions and thus confirm the acceptability of the safety analysis.

Proponent	SED
Technical Advisor/Evaluator	SED (J.K. Khosla)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

2.239.1 Installation and Training in the Use of Aerosol Computer Codes

The services of AECL staff are required to install certain aerosol computer codes on our computers and to provide training to AECB staff to enable them to run these codes efficiently. This would also include consultation after the initial installation. Such services would be required on an 'as needed' basis.

Experience in the use of licensees' computer codes has indicated that an excessive amount of time could be spent by AECB staff in getting some of the codes to run on our computers. AECL staff familiar with these codes would assist us in reducing the start-up time and in running them more efficiently.

The review of aerosol computer codes is required as part of our safety assessment of the CANDU-6 and CANDU-3 reactors.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Truong)
Project Manager	Q.S. Truong
Review Panel	
Contractor	AECL
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$15k	\$0k	\$0k	\$15k

Earlier Directly-Related Contracts and Funding:

2.240.1 Geophysical Data Analysis - Darlington & Pickering Region

It is proposed to undertake a compilation and an analysis of all magnetic and gravity data at a scale of 1:1,000,000 in a large region surrounding the Darlington and Pickering nuclear generating stations. It is also proposed to compile and analyze similar data at a scale of 1:50,000 near the nuclear stations themselves.

This work is proposed to determine if there are major geophysically-expressed lineaments in the immediate vicinity of the Darlington and Pickering nuclear generating stations, other than those identified in AECB INFO-0342, and to obtain an independent assessment of whether all, including those identified in that report, may be faults.

It is anticipated that this study will reveal all major geophysically-expressed lineaments that occur in the region surrounding the nuclear plants and may point out which of those are likely to be faults. This information will be factored into that already obtained which is relevant to assessing the likelihood of a major earthquake occurring at Darlington and Pickering.

Proponent	RSD 'A'				
Technical Advisor/Evaluator	RDS 'A' (J.L. Wallach)				
Project Manager	J.L. Wallach				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

2.217.1 \$238,000

2.241.2 Technical Review of the CANDU-3 PSA (Phase 2)

It is proposed to fund a contract to review the CANDU-3 Probabilistic Safety Assessment to identify major safety concerns. This phase would provide a more detailed examination of the ranked issues, following the completion of Phase 1.

To date, the AECB has had limited resources to devote to review of the CANDU-3 PSA. Beginning such a review is desirable.

The results of the contract would be used in the continuing review of the CANDU-3 PSA.

Proponent	SED				
Technical Advisor/Evaluator	SED (K. Asmis)				
Project Manager	D.J. Martin				
Review Panel					
Contractor	Pickard, Lowe and Garrick				
Principal Investigator	K. Fleming				
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$46k	\$0k	\$0k	\$46k

Earlier Directly-Related Contracts and Funding:

2.219.1	\$50,000
2.219.2	\$22,000

3.101.2 Demonstration of the Feasibility of Directly Dating Quartz (2)

It is proposed to obtain samples of rock, the ages of which lie for the most part within the range of from about 400 million years to 1,000 million years, and date them using the electron spin resonance dating technique developed in Phase 1.

This study is proposed in order to establish conclusively that a linear relationship exists between the strength of the electron spin resonance signal and the age of the quartz. This apparent relationship was discovered in the previous study by evaluating samples in the age ranges of from 100 thousand to 400 million years and from 1 billion to 1.4 billion years. However, there is a 600 million-year data gap between those two groupings and this has to be filled in order to confirm or deny the relationship.

It is anticipated that the results of this study, if they establish that the linear relationship exists, will eventually be useful for determining the age of last movements along faults. This will, in turn, provide a means for determining whether or not an area is tectonically stable which, of course, has implications for seismic hazard and seismic risk estimates relevant to nuclear facilities. The ages of interest in this application are much younger than those to be tested during this study. However, it is necessary to establish reliably that a linear relationship exists over the entire age range before the method can be used as a trustworthy indicator of recent tectonic stability.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	16
Contractor	Odom, A.L.
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$0k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

3.101.1 \$52,000

3.103.1 Absorbed Fraction of Ingested Uranium in Humans

It is proposed to determine the absorbed fraction of ingested dietary uranium (from both food and drinking water) in persons living near certain nuclear facilities, by measuring the content of uranium in their diet and in their fecal and urinary excretions.

The currently used annual limit on intake (ALI) for uranium, by ingestion, is derived using a value of 0.05 for the absorbed fraction of ingested uranium. This value is known to have a number of uncertainties, and more work should be done to improve its accuracy.

The results of the study are expected to improve the value for the absorbed fraction and hence the estimate of the ALI (oral) for uranium. (This project is proposed to be done jointly with the Bureau of Radiation and Medical Devices of NHW. Their contribution will consist of the laboratory analyses to be undertaken for this project.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy, M. Measures)
Project Manager	K.P. Ho
Review Panel	04
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$60k	\$20k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

3.111.1 Evaluation of Data and Models on Uranium Metabolism - Europe

It is proposed to continue to fund the compilation of currently known data regarding the intake, transfer (among organs), retention, and excretion rates of uranium in uranium workers, with a view to: testing currently available metabolic and dosimetric models with different data sets; comparing computed excretion patterns to the observed ones; and determining which model describes best the known data (or how a selected model should be modified to fit the observed data).

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB Radiation Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with a state-of-the-art metabolic and dosimetric model for uranium intake. This model will be compared to the one derived in 3.111.2.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	04
Contractor	Centre d'Etudes Nucléaires de Fontenay-aux-Roses
Principal Investigator	Dr. P.G. Beau
Category	0

Past	90/91	91/92	92/93	Future	Total
\$18k	\$10k	\$11k	\$0k	\$0k	\$39k

Earlier Directly-Related Contracts and Funding:

3.111.2 Evaluation of Data and Models on Uranium Metabolism - North America

It is proposed to test and validate currently available metabolic and dosimetric models for uranium. This will be done with data, obtained from animal experiments and human exposure, that have been, or will be, critically reviewed. Computed excretion patterns will be compared with observed ones. The best predictive models will be identified and improvements to them will be made, if necessary.

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB Radiation Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with the state-of-the-art metabolic and dosimetric models for uranium intake. This model will be compared to the one derived in 3.111.1.

Proponent	RPD				
Technical Advisor/Evaluator	RPD (F. Horvath)				
Project Manager	P. Duport				
Review Panel					
Contractor	Radiation Surveillance Associates				
Principal Investigator	Dr. M.E. Wrenn				
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$10k	\$50k	\$0k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

3.111.1 \$10,000

3.123.1 Influence of Macrophages on Dissolution of Uranium Compounds

It is proposed to study, in the laboratory, the influence of macrophages, oxygen and carbon dioxide on the in vitro dissolution rates of uranium compounds, as a function of the chemical forms and particle sizes of these compounds. (Macrophages are specialized cells whose function is to destroy bacteria and foreign materials that enter an organism.) The results of the in vitro solubility tests will be compared to clearance rates of the same uranium compounds deposited in the tracheal lobe of the respiratory system of sheep.

Experimental data on the biokinetics of uranium in man are not consistently compatible with in vitro solubility rates (of the same compounds) which are widely used in current dosimetric models. Recent information from laboratories of the French Atomic Energy Commission (Service of Experimental Pathology) indicates that the solubility rate of uranium compounds is significantly enhanced by the presence of macrophages in, and by the addition of oxygen to, simulated lung fluid. The solubility rates observed under these experimental conditions seem to represent more accurately the clearance rates observed in man. The solubility rate of radioactive material is an important parameter of metabolic and dosimetric models, and it is necessary that AECB staff know, and use, the most realistic and accurate parameters in these models, whether for determining regulatory exposure limits or for deriving bioassay guidelines for accidental or routine radiation exposures. The proposed study would be designed on the basis of the procedures developed and tested by the French Atomic Energy Commission and on the use of sheep as an experimental animal. It has been shown that the respiratory tract of sheep, with its tracheal lobe that branches directly from the trachea, lends itself to localized deposition of test materials without impairing significantly respiratory functions. However, these procedures would be used in parallel with procedures developed in previous AECB studies, with a view to correlating data of past and future solubility tests.

It is anticipated that the results of the study will provide the AECB with realistic solubility parameters to be used for the determination of bioassay guidelines, and for exposure and dose calculations. It is also anticipated that the results will be used to develop a laboratory procedure to determine, accurately and economically, solubility rates and lung clearance rates of uranium compounds.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	05
Contractor	University of Sherbrooke
Principal Investigator	R. Bégin
Category	0

Past	90/91	91/92	92/93	Future	Total
\$54k	\$60k	\$60k	\$10k	\$0k	\$184k

Earlier Directly-Related Contracts and Funding:

3.125.1 Study of Chemical Toxicity of Uranium Hexafluoride

It is proposed to investigate the chemically toxic effects, in humans, from accidental acute releases of uranium hexafluoride in uranium conversion plants.

The chemical toxicity of uranium and fluorine are known individually. However, during an accidental release of uranium hexafluoride in a conversion plant, it is probable that an acute uptake of uranium by workers will be associated with an acute uptake of the fluoride. The tests to determine if a worker may have suffered damage to his organs are based primarily on the results of uranium excretion patterns and kidney function assessments. This work is proposed because it appears that there is insufficient information available on the toxic effects due to the combination of uranium and fluorine in the compound uranium hexafluoride.

It is anticipated that the proposed research will provide information on the health effects of uranium hexafluoride on humans from accidental acute releases in conversion plants. The gathered information may also be used in the development of action level guidelines concerning the return of acutely-exposed workers to their normal duties. (This project will begin with a literature review; if insufficient information is found, then an animal study will be considered to gather the required information. The costs below reflect the estimated cost for a literature review only.)

Proponent	UFD, RPD					
Technical Advisor/Evaluator	UFD (A. Ghosh), RPD (M. Measures)					
Project Manager	K.P. Ho					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$20k	\$0k	\$0k	\$20k	

Earlier Directly-Related Contracts and Funding:

3.134.1 RBE from a Microdosimetric Approach

It is proposed to conduct a critical review of the literature on the state-of-the-art of the relationship between radiation-matter interactions in cell components and the Relative Biological Effectiveness (RBE) of high linear energy transfer radiation with an emphasis on the effect of alpha radiation on the cells of human bronchial epithelium.

In spite of elaborate laboratory experiments and epidemiological studies, risk coefficients for specific types of radiation are determined with uncertainties, at best, of the same magnitude as the variable being determined; in some cases, uncertainties are as large as one order of magnitude. An important parameter in establishing risk coefficients is the RBE of the type of radiation under consideration. Microdosimetry has been a powerful tool in the study of radiation-matter interaction in living cells, and of the changes induced in cell components at the molecular level. The continuous refinement of microdosimetric models has led progressively to a better understanding of radiation effects in the case of radionuclides incorporated in cell components, as well as that of exposure to external radiation. It seems, at present, that convergent efforts in epidemiology, animal experiments and microdosimetry are necessary to determine the RBE, and therefore the risk, more accurately. At a time when regulatory limits on exposure to radon daughters tend to be revised downward, it is important to understand, as well as possible, the mechanisms that lead from irradiation of lung tissues by alpha particles to malignancies in order to support regulatory decisions.

It is anticipated that a critical review of the state-of-the-art research on the relationship between radiation-matter interaction and biological modification at the nucleus, chromosome, or gene levels in the cell will provide necessary information to AECB staff in this domain and will strengthen the scientific bases upon which regulatory decisions are made.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$0k	\$0k	\$20k

Earlier Directly-Related Contracts and Funding:

3.144.3 Paleoseismicity in the Saguenay Region

It is proposed to search for additional liquefaction features produced by the Saguenay earthquake in the Saguenay-Charlevoix region. Once located, detailed investigations involving the excavation of trenches, documentation features in-situ and laboratory analyses of organic and inorganic sediments would be carried out. It is also proposed to continue documenting evidence of seismicity which may have occurred in that area prior to the recording of historical earthquakes (paleoseismicity).

This study is proposed because detailed documentation and evaluation of sand boils, begun during the summer of 1989 and continued in 1990, was completed for only 4 or 5 such features, and in a very localized area. There is a need to record data over a wider area, in order to determine whether or not a particular pattern or set of characteristics emerges and ultimately to establish, if possible, a well-founded set of criteria for recognizing evidence of paleoseismicity and the age, or ages, of such events. The application of results of this work is particularly important to areas in which seismic events have not been reported in historical time.

It is anticipated that the results of this study will provide the means for establishing criteria to recognize the effects of previous earthquakes and will also possibly aid in extending our knowledge of the seismic record in part of eastern Canada further back in time than historic seismic records allow. Should the anticipated results be realized, the AECB will be in a clear, defensible and unequivocal position to require licensees of existing, or applicants of future, nuclear facilities to conduct paleoseismic studies, particularly in areas which are not known to have experienced earthquake activity in historical times.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Columbia University
Principal Investigator	M. Tuttle
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$37k	\$60k	\$0k	\$97k

Earlier Directly-Related Contracts and Funding:

3.144.1	\$13,000
3.144.2	\$57,000

3.146.1 Canadian Atmospheric Stability Indicators

It is proposed to fund a study to collect data which would be used to develop a method for using routine meteorological data to deduce atmospheric stability at Canadian reactor sites. Atmospheric stability is a key factor in predicting atmospheric concentrations under release conditions. The method should be applicable to other licensed facilities in Canada, such as uranium refineries.

In order to calculate the concentrations of radioactivity in the air following a release from a nuclear facility, the stability of the atmosphere must be specified. Since atmospheric turbulence is difficult to measure, this is normally done indirectly through simple indicators that are known to be correlated with direct turbulence estimates. (Temperature gradients as indirect turbulence indicators, are frequently used in accident analysis and emergency response programs.) However, these correlations between the direct and indirect indicators were developed in England and in the southern U.S. and are inappropriate for the Canadian climate, particularly in the winter when the ground is snow covered.

The results of the project are intended to provide a method to deduce atmospheric stability from simple, routine meteorological measurements for the Canadian climate, and so improve the AECB's confidence in predicted atmospheric radionuclide concentrations following releases from nuclear facilities.

Proponent	SED, RPD, HES					
Technical Advisor/Evaluator	SED (L. Truong), RPD (R. Chatterjee, R. Irwin)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k	

Earlier Directly-Related Contracts and Funding:

3.150.2 Effects of Radiation on Species Other than Man: Aquatic Organisms

It is proposed to determine, in the laboratory, whether the deformities observed in a large number of insect larvae (chironomids) in Port Hope Harbour are due to radiation.

Radium and uranium refining operations have contaminated the sediments of Port Hope Harbour with radionuclides of the U-238 and Th-232 decay chains. The sediments are also contaminated with other heavy metals such as Fe, Cu, Pb and Ni. In a recent study, it was found that 83% of the chironomus species present in the more heavily polluted inner harbour had deformed mouth parts, whereas only 14% of the chironomids in the outer harbour were deformed. The authors suggested that radiation may have induced these deformities. The proposed laboratory study will determine whether the effects observed are indeed caused by radiation.

It is anticipated that the results of this study will determine whether chironomids could serve as an efficient biological indicator of contamination of the environment by radioactive substances, and provide additional insight into the effects of radiation on species other than man.

Proponent	RPD
Technical Advisor/Evaluator	RPD (M. Measures)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

3.150.1 \$46,000

3.151.1 Canadian Data Base for Radionuclide Transfer in the Environment

It is proposed to construct a computer database for radionuclide transfer parameters in the Canadian environment.

This project is proposed because the lack of adequate (site specific) data on parameters used to predict transfer of radionuclides in the environment often leads to global use of data from relatively few sources. However, Canada has now acquired a substantial amount of data from studies done by several industries and universities, some of it through AECB funding. These data are often preferable for Canadian applications and exist in published, but more often in unpublished, reports. There is a clear need for a central data source that represents Canadian experimental conditions and is amenable to future updates and that is easily accessible to Canadian investigators and others, including the AECB. This project will define the necessary scope of the data base, select the operating methods (software, repository of the data base, etc.), and will acquire, record and interpret suitable data.

It is anticipated that this project will provide AECB staff with convenient access to a comprehensive and centralized data source, which can be used for evaluating licensees' submissions for emission limits.

Proponent	RPD
Technical Advisor/Evaluator	RPD (K. Bundy, T. Tostowaryk)
Project Manager	K.P. Ho
Review Panel	
Contractor	Atomic Energy of Canada Ltd. - WNRE
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$16k	\$0k	\$46k

Earlier Directly-Related Contracts and Funding:

3.152.1 Production of Public Information Material on the Effects of Radiation

It is proposed to produce a bilingual, non-technical video and accompanying brochure of up-to-date information on the effects of radiation on humans and on the environment.

At present, there are only a few commercially available video productions on the effects of radiation. Most of these videos are produced in the U.S.A. and are relatively old. AECB staff have been using this information material for training purposes and to inform the public about the effects of exposure to radiation. However, AECB staff feel strongly that these videos are outdated and of limited usefulness. Furthermore, little has been produced about the effects of radiation on the environment. This project is proposed because it is felt that up-to-date information in video format (with accompanying brochure), in both official languages, is urgently needed to carry out effective public information programs.

The product of this work will help AECB staff to disseminate, in an effective manner, appropriate, factual and up-to-date information to the Canadian public on the effects of radiation on humans and the environment. These materials also will enhance the visibility of the AECB.

Proponent	RPD				
Technical Advisor/Evaluator	RPD (R. Chatterjee), OPI (H. Spence)				
Project Manager	R. Avadhanula				
Review Panel					
Contractor					
Principal Investigator					
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$50k	\$50k	\$0k	\$0k	\$100k

Earlier Directly-Related Contracts and Funding:

3.154.1 Optimization of Doses between Atomic Radiation Workers and the Public

It is proposed to study the impact, within the framework of the ALARA principle, on members of the public resulting from a dose reduction to atomic radiation workers in a nuclear facility.

In operations such as mining, one of the main controls that is used to reduce radiation exposure is to increase the ventilation in the work areas. This in turn, might cause the radioactive emissions to increase and to be dispersed into the environment which might subsequently result in the public receiving a greater dose of radiation. It is therefore proposed that a study be undertaken to determine what impact the reduction of dose to workers in a nuclear facility will have on the dose to members of the public.

It is anticipated that this study will help AECB staff to assess the ALARA submissions from its licensees.

Proponent	RPD					
Technical Advisor/Evaluator	RPD (S.H. Ching)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$25k	\$25k	\$0k	\$50k	

Earlier Directly-Related Contracts and Funding:

3.155.1 Validation of Environmental Pathways Analysis Models

It is proposed to review the progress of, and possibly participate in, the relevant international coordinated research programs aimed at validating environmental pathways analysis models. It is also proposed to evaluate critically the outcome of these programs with a view to identifying whether there is a need for significant changes to the pathways analysis models, currently used by the licensees as approved by the AECB.

In the wake of the Chernobyl nuclear reactor accident, several national (mostly European) and international agencies have been involved in estimating the radiation dose to members of the public through various environmental pathways analyses. During the course of these efforts, it was generally recognized that there were wide variations in the dose predictions, and that the variations depended on the model used. As a result, two international coordinated research programs, called Validation of Model Predictions (VAMP) and Biospheric Model Validation Study (BIOMOVs), have emerged; the former was organized by the IAEA and the latter by the Swedish National Institute of Radiation Protection. Environmental pathways analysis models are used by AECB licensees to derive release limits for nuclear facilities and to predict doses to members of the public from waste management practices. This project is proposed because AECB staff review and assess the models used and the dose estimations prepared by its licensees.

It is anticipated that a critical evaluation of the results of the relevant international programs, and participation in such programs, by AECB staff will help to ensure the credibility of modelling activities in Canada and regulatory decisions based on such modelling. Joint funding, from other interested Canadian agencies, will be sought.

Proponent	RPD, HES					
Technical Advisor/Evaluator	RPD (R. Chatterjee)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	0					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$30k	\$80k	\$80k	\$0k	\$190k	

Earlier Directly-Related Contracts and Funding:

3.156.2 Geology at an Apparently Seismically Active Intersection

It is proposed to examine and evaluate outcrop-scale faults in the vicinity of an apparently seismically-active intersection near Lac St-Jean, Québec. The work will involve measuring fault orientations, determining the nature of faulting and identifying the faults along which repeated movements may have occurred.

This study is proposed because of the presence of intersecting major lineaments, a situation which is similar to that in the immediate vicinity of the nuclear power plants at Darlington and Pickering. The intersection in the Lac St-Jean area appears to be the centre of microseismic activity, whereas no information currently exists to make a similar pronouncement for the intersection in the area of the nuclear plants.

It is anticipated that the results of this study will provide information on brittle faulting in a seismically active, intraplate area marked by major, intersecting lineaments. If so, the results will be applicable to preparing guidelines and assessing the claims made by licensees regarding the seismogenic potential of the geological environment encompassing the nuclear power plants.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Université du Québec à Chicoutimi
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$40k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

3.156.1 \$20,000

3.157.1 A Field Evaluation of Convolved Laminations

It is proposed to select at least three exposures in which convoluted laminations occur and thoroughly map the structures and the entire sedimentary sequence. The environment of deposition will be determined and the origin of the convolutions will be assessed in light of the sedimentary environment. Experimental work may be a part of this study. This project has been endorsed by MAGNEC.

This study is proposed because convoluted laminations are indicators of a sudden shock being applied to water-laden sediments. They are fairly common in the unconsolidated glacio-fluvial sediments of eastern Canada, but their origin is in question. There are classical interpretations related to rapid sedimentation, ice loading or boulders dropping into sediments from freely floating, but progressively melting, ice blocks. However, there is the distinct possibility that they are caused by earthquakes, whether tectonically induced or triggered by sudden shocks attendant upon glacial rebound. Knowledge of the origin of these features could have implications for seismic risk assessments.

It is anticipated that the results of this study will provide evidence that all convolutions do, or do not, form in the same sedimentary environment. If the former, then field evidence would suggest that a sedimentary origin is very likely, although seismicity cannot be ruled out. If, however, these structures form under a variety of sedimentary conditions and if these include quiet water conditions, a seismic origin would seem rather likely.

Proponent	RSDA					
Technical Advisor/Evaluator	RSDA (J.L. Wallach)					
Project Manager	J.L. Wallach					
Review Panel						
Contractor	University of New Brunswick					
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$25k	\$25k	\$45k	\$95k	

Earlier Directly-Related Contracts and Funding:

3.160.1 Radionuclide Analysis in Dissolution Tests

It is proposed to measure the quantity of uranium in samples obtained from in vitro assays in which the solubility of uranium ore dust particles is tested in the presence of lung macrophages.

The University Hospital of Sherbrooke (Quebec) (CHUS) is carrying out a research project for the AECSB, aimed at determining the influence of lung macrophages on the solubilization of radionuclides contained in uranium ore particles. This research is the first known attempt to use macrophages in dissolution tests of uranium ores. No information exists in the literature on the subject. The requested analyses are necessary to guide the CHUS in determining the optimum quantities of macrophages and uranium ore dust compatible with realistic biological conditions and good analytical sensitivity.

It is anticipated that the results of this project will provide analytical data for adjusting parameters and optimizing dissolution procedures.

Proponent	RPD					
Technical Advisor/Evaluator	RPD (F. Horvath)					
Project Manager	P. Duport					
Review Panel						
Contractor	Becquerel Laboratories Inc.					
Principal Investigator	Dr. R. Robertson					
Category	0					
	Past	90/91	91/92	92/93	Future	Total
	\$0k	\$12k	\$3k	\$0k	\$0k	\$15k

Earlier Directly-Related Contracts and Funding:

3.123.1 \$184,000

3.161.1 Radiation Facts Booklet

It is proposed that an illustrated, easy-to-read and uniquely Canadian radiation facts booklet be prepared by combining, up-dating and Canadianizing the best of existing publications of this nature, such as the U.K. NRPB's "Living with Radiation". (The booklet would be complemented by, and coordinated graphically with, the print product of project 3.152.1.)

No definitive Canadian reference of this nature exists, and none is in preparation. While there are a number of nuclear industry brochures that address the topic on a limited basis, for conflict of interest/public perception reasons these are not suitable for distribution by the AECB. One produced by the Canadian Institute for Radiation Safety (CAIRS) with AECB collaboration has a special emphasis on uranium mine and mill workers, and is also too narrow in scope. International versions of such a document have proven less than satisfactory for AECB purposes - they are extremely expensive, there is no Canadian content, and the most recent one from the IAEA contained two serious errors of fact.

This project would provide an information vehicle visibly identified with the AECB, for use in public communications programs, including media relations; worker training (licensees); youth education activities (it might be adopted as an official reference for science classes); and for orientation training of new AECB staff.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence), RPD (C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

3.162.1 Monitoring Uranium Emissions from a UF₆ Plant Stack

It is proposed to assess the representativeness, consistency, and accuracy of the sampling of contaminants released through the stack at the Cameco West UF₆ Plant in Port Hope. The design of the stack and the performance and suitability of an isokinetic sampling device (developed by TSI Corporation) will be evaluated with reference to the Method 5, Source Testing Code, of the Ontario Ministry of the Environment.

Investigations by Cameco indicated that the design of the stack was flawed such that accurate estimate of the emissions would be difficult. Subsequent modifications to the stack to provide better monitoring of uranium emissions did not prove successful. The company then installed a new sampling technique called the TSI Static Isokinetic Sampling. To date, the stack design and the method of sampling have not received the approval of the Ontario Ministry of the Environment nor that of Environment Canada. It is important for the AECB to evaluate whether the present stack design and monitoring technique are suitable for assuring compliance with the facility licence.

It is anticipated that the results of this project will enable AECB staff to determine whether the design of the stack and the TSI or other monitoring techniques are compatible. (Cost sharing will be sought from Environment Canada and the Ontario Ministry of the Environment.)

Proponent	UFD
Technical Advisor/Evaluator	UFD (A. Ghosh)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$80k	\$0k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

3.163.1 The Origin of Conical Hills, Charlevoix Seismic Zone

It is proposed to cut trenches in, and evaluate exposures of, conical hills on the Gouffre River terrace north of Baie St. Paul, Québec.

This work is proposed because these post-glacial features occur in the heart of the Charlevoix Seismic Zone and appear to have formed as a result of the upward movement of liquefied sand and gravel which domed the overlying sediments. The origin of this movement, however, is not certain as there has been very little time to evaluate the internal structure of these hills. Thus detailed mapping is required to confirm or deny the aforementioned working hypothesis.

It is anticipated that the results may suggest a seismic origin for the hills which, if so, will provide geological evidence of earthquake activity. The results could then be used in areas in which no major seismic activity has been recorded to date, but in which there may, nonetheless, have been major seismic activity prior to recording of such events. As in the case of the other seismotectonic projects, this information could be used by the AECB to develop requirements for seismic hazard assessments for proposed or existing nuclear facilities.

Proponent	RSDA					
Technical Advisor/Evaluator	RSDA (J.L. Wallach)					
Project Manager	J.L. Wallach					
Review Panel						
Contractor	L'Université de Laval					
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$30k	\$30k	\$0k	\$60k	

Earlier Directly-Related Contracts and Funding:

3.164.1 Carbon-14 in Lakes: Appropriate Risk Assessment

It is proposed to assess the relative degree of carbon-14 contamination in the water, in sediments, and in biota of two Canadian Shield lakes that historically received deliberate carbon-14 additions. These data will be used to test current risk assessment methodology for carbon-14 in aquatic systems.

This project is proposed because current assessment philosophy relies on specific activity or transfer coefficients from water to biota to assess the radiological risk to humans from C-14 in aquatic ecosystems. Because of dilution and degassing, accidental releases of C-14 to water bodies result in transient C-14 concentrations in water. Thus, current assessment philosophy assumes a transient risk to humans. However, some of the added C-14 may be biologically incorporated by algae and enter the food chain. Here C-14 may persist and be transferred into the human food chain via fish. At the Experimental Lakes Area in northwestern Ontario an opportunity exists to study this risk in two lakes which received C-14 additions in the 1970s. Work on one of these lakes in the past year has shown that over 35% of the added C-14 persists in sediment. By assessing the degree of contamination of specific biological compartments in these lakes the long-term retention in different compartments associated with accidental C-14 release to water bodies can be evaluated.

It is anticipated that this project will provide AECB staff with data to evaluate the long-term consequences of C-14 release to aquatic systems.

Proponent	RPD					
Technical Advisor/Evaluator	RDP (R. Chatterjee)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$35k	\$35k	\$0k	\$70k	

Earlier Directly-Related Contracts and Funding:

3.165.1 HTO and C-14 Cycling following Chernobyl

It is proposed to evaluate the uptake and cycling of HTO and C-14 following the Chernobyl accident by measuring the distribution of these two nuclides in the cellulose from the annual rings of trees collected from the Chernobyl area.

In severe accidents, HTO and C-14 may be released from CANDU reactors. Releases of HTO and C-14 did occur during the Chernobyl incident. However there has been little study of these two isotopes in the environment surrounding Chernobyl. Analyses are needed to compare the cycling of HTO and C-14 following a severe accident with results derived from continuous operations. Data bases from continuous operations are available already from work done for the Canadian Fusion Fuels Technology Project (CFFTP), CANDU Owners Group (COG) and AECL Research by R.M. Brown.

It is anticipated that this work will complement international efforts led by the IAEA to evaluate the cycling of other nuclides (e.g. Cs-137) following Chernobyl.

Proponent	RPD					
Technical Advisor/Evaluator	RPD (T. Tostowaryk, M. Measures)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k	

Earlier Directly-Related Contracts and Funding:

3.166.1 Historical Seismicity Study of Prince Edward County Area, Ontario

It is proposed to evaluate the historical seismicity of Prince Edward County, Ontario, and adjacent parts of Ontario and New York State.

This work is proposed to complement the tectonic studies undertaken for the AECB by G.H. McFall of the Ontario Geological Survey. Her work has indicated: a) the existence of several heretofore unknown geological structures; b) the presence of an alignment of earthquakes which trend NW from the southeastern corner of Lake Ontario to Prince Edward County; and c) the continuation of the seismically active Clarendon Linden Fault in New York State across Lake Ontario to, and along, the Salmon River Fault in southern Ontario. Her work is now changing the perception of the tectonic setting and seismic potential of the area. However, one of the major elements remaining to be addressed is a complete documentation of the historical seismicity.

It is anticipated that the results of this study will verify or refute the existence of the NW seismic trend, and will demonstrate that there has or has not been seismic activity along the Salmon River and other major faults in the area.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$30k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

3.131.1	\$25,000
3.131.2	\$25,000

3.167.1 Effects of Microdistribution of Tritium on Dose Calculations

It is proposed to review and evaluate the existing literature on the microdosimetry of tritium. This review will focus on the relationship between distribution of tritium and radiation dose, both at the cellular and tissue levels. It will also assess whether microdosimetric considerations would support a quality factor greater than unity for tritium which has been incorporated into organ and tissue cells.

Conventional methods for calculating the radiation dose delivered to human tissues by tritium assume that the energy is uniformly deposited in all the cells of an organ. This assumption is supported by the fact that tritium is usually incorporated as tritiated water and is homogeneously distributed in the body fluids. However, recent studies indicated that tritium-labelled organic compounds (organically-bound tritium) concentrate in specific organs and tissues of the body, and even in specific areas within the cell. Consequently, doses to these cells and organs may be significantly higher than would be the case for a homogeneous distribution of tritium.

The results of this review will help AECB staff to evaluate the significance of the non-uniform distribution of tritium and whether or not the distributional effects should be accounted for in the calculations of the dose equivalent (by the use of the 'N' factor), and will clarify the knowledge on the quality factor for tritium. The results of this project, in concert with those of 3.135.1 (Measurement of Tritium in Canadian Food Items), gives information on the metabolism and retention of organically-bound tritium in tissues, which will allow AECB staff to suggest improvements to the dosimetry programs for tritium submitted by its licensees.

Proponent	RPD
Technical Advisor/Evaluator	RPD (M. Légaré)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$0k	\$0k	\$20k

Earlier Directly-Related Contracts and Funding:

3.168.1 Possible Toxic Effects of Heavy Water Plant Effluents on Livestock

It is proposed to determine whether statistically significant correlations exist between effluents from the Bruce Heavy Water Plant and detrimental health effects, which may have resulted in as-yet unexplained deaths of livestock (sheep) on a particular farm near this facility.

This study is proposed because an earlier investigation by Agriculture Canada of the animal husbandry practices on the farm in question did not uncover any sign of toxic substances in the farm animals which died from still-unknown causes. Since no obvious cause of death has been determined, it would be advisable for the AECB to investigate whether any statistically significant correlation exists between the nature and concentrations of effluents from the Bruce Heavy Water Plant and the conception, gestational period and lifetime of the sheep which died. Similar correlations will be investigated between these effluents and those survivors which were conceived or born at about the same time.

It is anticipated that this study should reveal whether the causes of death of any animals have been attributable to the operation of the heavy water plant. (This project is expected to be carried out with the assistance of Agriculture Canada and possibly other interested federal or provincial agencies.)

Proponent	PRDB
Technical Advisor/Evaluator	PRDB (M. Taylor), RPD (T. Tostowaryk)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

3.169.1 Computer Software Quality Assurance

It is proposed to obtain consulting services concerning quality assurance for analytical software used in nuclear engineering. The consultants would review the types of analytical software used in nuclear engineering, including those to be covered by the proposed Canadian Standards Association (CSA) quality assurance standard in the N286 series and recommend to AECB staff appropriate quality assurance approaches and procedures for the design, development and maintenance of such software.

AECB staff is required to assess licence submissions concerning the predicted performance of nuclear reactors and nuclear waste disposal facilities. Most of these performance predictions are generated by software modelling packages currently under development by industry and government agencies. Confidence that all of the requirements associated with model design, development and testing have been identified and implemented, is dependent on the effectiveness of the software quality assurance programme. AECB staff are participating in a CSA committee to establish a quality assurance standard in the N286 nuclear series applicable to analytical software such as codes to simulate thermohydraulic processes or software tools to perform Computer Aided Design.

This activity will assist AECB staff in assessing the effectiveness of the licensees' quality assurance programme, and in contributing more effectively to the N286 analytical software committee.

Proponent	CQAD, WMD, SED					
Technical Advisor/Evaluator	CQAD (D. Scrimger), WMD (P. Flavelle), SED (J. Khosla)					
Project Manager	Q.S. Truong					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k	

Earlier Directly-Related Contracts and Funding:

4.101.1 Study of the Health Effects of Inhaled Uranium Ore Dust

It is proposed to provide funding for the ongoing project to study the health effects (induction of cancer of the lung, cellular defects) on experimental animals exposed to different concentrations of airborne high grade uranium ore dust. Inter-organ transfer of radionuclides, such as uranium, radium and thorium, and the rate of clearance of these radionuclides from the lung will also be studied.

This study was undertaken because Canadian uranium miners are exposed to airborne mineral dust that contains uranium, thorium, and all their decay products, some of which are highly radiotoxic. In high grade ore mines, uranium content in the dust may reach several tens of percent and may represent the predominant occupational radiation hazard. Since uranium miners have always been exposed to a mixture of external gamma radiation and internal radiation from radon decay products and ore dust, it has not been possible to separate the contribution of each component to the observed rate of lung cancer. This was of little consequence as long as radon daughters were the predominant hazard, but this becomes an issue in today's Saskatchewan mines. Since the initiation of this project, the following results have been obtained: an apparatus that generates stable high concentrations of uranium ore dust has been built and tested; an on-line aerosol particle sizer monitors continuously the concentration and size distribution of the dust to which the animals are exposed; a nose-only inhalation apparatus (for rats) has been built (according to past experience at the U.K. National Radiological Board) and tested; the renal toxicity of high grade uranium ore dust has been studied and the maximum tolerable (in the short-term) lung burden determined; the resistance of a North American breed of Sprague-Dawley rats to a cancer promoter (5,6-benzoflavone) has been verified. A preliminary long-term (14-week) inhalation experiment has been initiated to determine optimum exposure

In addition to the partial information already obtained, it is anticipated that this study will indicate whether inhaled high grade uranium ore dust induces lung cancer in rats whose response to radon daughters is already known. Short- and long-term metabolism of the most significant naturally-occurring radionuclides will also be studied and the data will be used to refine current internal dosimetric models.

Proponent	UFD, RPD, HES
Technical Advisor/Evaluator	UFD (A. Balint), RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	03
Contractor	MacLaren Plansearch Inc.
Principal Investigator	A. Van der Vooren
Category	0

Past	90/91	91/92	92/93	Future	Total
\$808k	\$150k	\$200k	\$0k	\$0k	\$1,158k

Earlier Directly-Related Contracts and Funding:

4.103.2 Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities

It is proposed to continue funding this project to determine experimentally the size distribution, the activity distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines and mills, refineries, conversion facilities and fuel fabrication plants.

This work is proposed to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters (size distribution, activity distribution, radionuclide composition and dissolution rate in simulated lung fluid) which are necessary to calculate the committed effective dose equivalent from exposure data must be determined in order to evaluate quantitatively this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the risk from long-lived particulates in uranium producing and manufacturing industries. It will also provide supporting information for any forthcoming regulation on long-lived dust and will facilitate interpretation of bioassay data for the purpose of the radiation protection of the workers at these facilities.

Proponent	UFD, RPD
Technical Advisor/Evaluator	UFD (G. MacDonald), RPD (F. Horvath, S. Ching)
Project Manager	K.P. Ho
Review Panel	05
Contractor	MacLaren Plansearch Inc.
Principal Investigator	A. Van der Vooren
Category	0

Past	90/91	91/92	92/93	Future	Total
\$159	\$85k	\$85k	\$15k	\$0k	\$344k

Earlier Directly-Related Contracts and Funding:

4.106.4 Ontario Miners Mortality Study - Annual Update

It is proposed to update the mortality, exposure and smoking data of the Ontario uranium miners for the three-year period 1987 to 1989 and annually thereafter until FY 1992/93, at which point a detailed mortality analysis will be conducted to obtain improved risk estimates.

The previous phases of the Ontario Miners Mortality Study have revealed that the update on an annual basis of mortality and histology data, as well as of exposure and smoking histories, is useful for detecting any annual trend in the mortality pattern, and any influence of yearly variation of smoking habits on the incidence of lung and other cancers among the aging population of Ontario uranium miners. Furthermore, the annual update may be pooled together about every five years and the updating of risk estimates may be achieved with minimum delay and cost.

It is anticipated that the results of this study will considerably improve the efficiency of the five-year mortality analysis for lung cancer risk estimates. Furthermore, the annual update will enable the AECB to detect annual trends in the mortality pattern, and the influence of confounding factors on the induction of lung and other cancers among the uranium miners. (This project is expected to be a joint study with Ontario Ministry of Labour (OML) and Workers' Compensation Board of Ontario (WCB) on a one-third cost-sharing basis.)

Proponent	UFD, RPD, HES, OML, WCB					
Technical Advisor/Evaluator	UFD (A. Balint), RPD (C. Pomroy, S. Ching)					
Project Manager	V. Elaguppillai					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$10k	\$10k	\$10k	\$30k	

Earlier Directly-Related Contracts and Funding:

4.106.1	\$60,000
4.106.2	\$180,000
4.106.3	\$53,000

4.112.1 Electrical Charge of Radioactive Aerosols in Uranium Mines

It is proposed to measure the fraction of positively and negatively charged aerosol particles carrying radon and thoron daughters, to determine the number of elementary charges carried by individual charged particles, and to relate these parameters to the ionization conditions and carrier aerosol parameters that prevail in underground uranium mine atmospheres.

The radiation dose delivered to the lung from inhaled radon and thoron daughters depends upon the deposition of these radioactive particles in the respiratory tract, which in turn depends on the size distribution and electrical charge of these particles. The aerosol size distribution itself is governed in part by the electrostatic attraction between ultrafine radon and thoron daughters and carrier aerosol particles generated by mining activities and diesel engines. Owing to the ionization induced by relatively large concentrations of alpha radiation emitters, the consequent phenomena (collectively referred to as "atmospheric electricity") play an important role in shaping the resulting radioactive aerosol actually inhaled by miners. To date, no study has been carried out in Canadian mines to determine the electrical properties of airborne radon and thoron daughters.

It is anticipated that the findings of this study will, for the first time, bring information to AECB staff on the electrical state of radioactive aerosols in mines. This information may also be used in interpreting monitoring and dosimetry data and may serve to complement the computer modelling of mine atmospheres.

Proponent	HES, EMR (J. Bigu)				
Technical Advisor/Evaluator	RPD (S. Ching)				
Project Manager	P. Duport				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$20k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

4.117.1 Evaluation of Long-Lived Dust Exposures from Silica Samples

It is proposed: a) to assess, from the available literature, to what extent dust samples (collected in Canadian uranium mines for the purpose of determining exposures to silica dust) are suitable for evaluating individual exposures to long-lived dust with an accuracy acceptable to the AECB; b) if warranted by the results of a), to determine experimentally the correlation between the mass of quartz collected (on total or respirable dust samples) and the alpha activity emitted by the long-lived radionuclides embedded in the dust particles; c) to determine the suitability and sensitivity of silica dust measurements for determining individual exposures to long-lived dust; and d) to evaluate the cost-effectiveness of the technically-acceptable monitoring method(s). This project will be undertaken, if required, only after a thorough AECB internal review of previous studies carried out by EMR on this subject.

The implementation of the Proposed General Amendments to the Atomic Energy Control Regulations will require that each and every radiation hazard present in the work place be taken into account for the determination of individual exposures. In the case of the uranium mining and milling industry, this will require that individual exposures to airborne long-lived dust be evaluated and entered, together with gamma, radon daughter and thoron daughter exposures, into a formula from which individual doses and committed effective doses will be calculated. At present, there is no method used routinely in Canadian mines that is known to be able to provide reliable information on long-lived dust exposure. However, silica (quartz) concentration in mine atmospheres is monitored routinely because of the risk to mine workers of silicosis. It is useful to study to what extent dust samples collected for silica monitoring are suitable for evaluating individual exposures to long-lived dust. Should these samples prove unsuitable for such an evaluation with the required accuracy, alternate methods, such as random spot sampling and the use of personal integrating monitors will be tested in order to determine the most cost-effective technique to be used to meet the upcoming regulatory requirements.

It is expected that this study will indicate to the AECB whether current silica dust samples can be used to evaluate individual exposures to long-lived dust in uranium mines and mills. In the event these samples are found to be unsuitable for this purpose, the study will indicate the most cost-effective method to be used to meet the regulatory requirements.

Proponent	UFD, HES
Technical Advisor/Evaluator	UFD (T.Viglasky), RPD (S. Ching)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$40k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

4.118.2 Mortality Analysis of Beaverlodge Uranium Miners from 1981-1989

It is proposed to update the mortality analysis of the uranium miners in Beaverlodge, Saskatchewan, from 1981 to 1989, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally, the cancer incidence data for this cohort from 1975 to 1989 will also be analyzed to improve the statistical significance of the mortality information which will be used to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Beaverlodge uranium miners for the period from 1950 to 1980 was about three times the values reported for the Newfoundland fluorspar miners, about three to six times the values reported for the Ontario uranium miners, and six to nine times the risk estimates obtained from the study of uranium miners in the Colorado Plateau. There is some concern, both nationally and internationally, about the accuracy of the risk estimate obtained from the study of Beaverlodge uranium miners. As a consequence, both the mortality data and radon daughter exposure estimates should be re-examined in order to reduce the uncertainties in the risk estimates. (The re-evaluation of radon daughter exposures for this group of uranium miners is being carried out in the previous study, 4.118.1.)

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This is expected to be a joint study with the National Cancer Institute of Canada on an equal cost-sharing basis.)

Proponent	RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (C. Pomroy, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	02
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$15k	\$45k	\$0k	\$60k

Earlier Directly-Related Contracts and Funding:

4.118.1	\$77,000
7.095.1	\$59,000

4.125.1 Exposure-Rate Effectiveness for the Induction of Lung Cancer

It is proposed to investigate the exposure-rate effectiveness for the induction of lung cancers among miners exposed to radon daughters. The exposure data for Ontario uranium miners, Newfoundland fluorspar miners, Beaverlodge and Port Radium miners, and for the U.S. uranium and Swedish metal miners will be analyzed statistically to derive a relationship between the induction of lung cancers and the exposure rate (in working level months/year) at which the miners were exposed to radon daughters at their respective work places.

Animal studies have shown that exposures to radon daughters at high exposure rates are less effective in inducing lung cancer (below the onset of cell-killing effects) than the corresponding exposures delivered at low exposure rates. It is prudent to investigate this phenomenon in human populations occupationally exposed to radon daughters. Since radon daughter concentrations in underground uranium and fluorspar mines (the latter at St. Lawrence, Newfoundland) during the early years of mining were substantially higher than those of today's miners, those early miners were exposed at higher exposure rates. To date, no comprehensive analyses of the exposure data of uranium miners in Canada and in the U.S., of fluorspar miners in Newfoundland, and of iron ore miners in Sweden, have been performed to facilitate a better understanding of the exposure-rate effectiveness for the induction of lung cancer among miners exposed to radon daughters.

The results of this study will improve AECB understanding of the exposure rate effectiveness and risk estimates for the induction of lung cancer following exposure to radon daughters.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elagupillai
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$10k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

4.126.1 Computerized Mortality Search Procedures

It is proposed to fund the preparation of a technical report which will document the structure of the files, methodology, flow of information, and data quality control checks used in the 1986 mortality search update of the Ontario miners study.

This project is proposed because, in the past decade, computer linkage methodologies have been improved greatly and new procedures have been developed. Weights have been derived for the parameters to be matched, and more links have been generated by using intermediate files to facilitate the linkage. Because updates to the mortality data bases are being proposed to be done on a five-year basis, it would be a logical step to document the methods being used, to facilitate future updates. The data from these studies are being used extensively, internationally, to improve the risk estimates for radiation-induced lung cancers.

The results of the technical report prepared could prove valuable for persons involved in any pooling of data on radiation workers. Recommendations for future improvements on record linkage will be made.

Proponent	RPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy, S. Ching)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$0k	\$0k	\$25k

Earlier Directly-Related Contracts and Funding:

4.130.1 Evaluation of Radon Daughter Exposures of Port Radium Miners

It is proposed to re-evaluate the radon daughter exposures (in working level months (WLM)) received by nearly 2100 miners who worked at the uranium mines in Port Radium in the Northwest Territories for the period from 1930 to 1960, and who may have had previous exposures to radon daughters in other mines.

The risk estimate for lung cancer obtained from the previous study of Port Radium uranium miners, by Howe et al., was 0.27% per WLM. This value is at the lower end of the range of relative risk estimates (0.3 to 3.3 % per WLM) reported for other Canadian and international studies (Ontario uranium miners 1.3%, Newfoundland fluorspar miners 0.9%, Beaverlodge uranium miners 3.3%, U.S. Colorado uranium miners 0.8%, Czechoslovakian uranium miners 1.8%, and Swedish iron miners 1.4%). Among the Canadian studies, exposures received by both the Ontario uranium miners and Newfoundland fluorspar miners were re-evaluated using improved techniques and additional information on exposure histories, which resulted in better agreement between their respective revised risk estimates (as stated above). The exposures received by the Beaverlodge uranium miners are being re-evaluated (project 4.118.1) and the results will be used in an updated mortality analysis (4.118.2). Therefore, it is important to re-evaluate the exposures of individual miners who worked in the uranium mines in Port Radium, taking exposures received by them in other mines into account as well as their work histories, and design characteristics of the mines.

It is anticipated that the results of this study will give the AECB improved exposure estimates for Port Radium uranium miners. These estimates will be used in an updated mortality analysis of Port Radium uranium miners (Project 4.130.2) to derive improved risk estimates for lung cancer due to exposure to radon daughters.

Proponent	UFD, RPD, HES					
Technical Advisor/Evaluator	UFD (D. Corkill), RPD (C. Pomroy, S. Ching)					
Project Manager	V. Elagupillai					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$55k	\$20k	\$0k	\$75k	

Earlier Directly-Related Contracts and Funding:

4.130.2 Mortality Analysis of Port Radium Uranium Miners (1950-1989)

It is proposed to update the mortality analysis of the uranium miners in Port Radium, in the Northwest Territories, for the period from 1950 to 1989, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally, the revised exposure estimates obtained from the previous project (4.130.1) will be used with the mortality data to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Port Radium uranium miners is known to have a number of uncertainties, including the uncertainty in its exposure estimates. Furthermore, since the previous analysis, several additional years of mortality data have been accumulated by the Canadian Mortality Data Base. It is therefore necessary to re-evaluate the risk of lung cancer per unit exposure to radon daughters, using both the revised exposure information (4.130.1) and the additional mortality data to the end of 1989.

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This is expected to be a joint study with the National Cancer Institute of Canada (NCIC) on an equal cost-sharing basis.)

Proponent	UFD, RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	UFD (D. Corkill), RPD (C. Pomroy)
Project Manager	V. Elagupillai
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$10k	\$40k	\$15k	\$65k

Earlier Directly-Related Contracts and Funding:

4.130.1 \$55,000

5.127.2 Radionuclide Concentrations in Fish: Phase 2 (Detailed Analyses)

It is proposed to determine the concentrations of radionuclides (uranium, thorium, polonium, and lead) in fish and in the associated water and sediments taken, during the Phase 1 program, from the fish-stocked lakes found downstream of the Elliot Lake uranium mines in the Serpent River Basin. Further, it is proposed that transfer parameters be calculated for each radionuclide (from sediments to water to fish to consumer).

Transfer parameters for the uranium and thorium decay series in aquatic ecosystems are important components in the estimation of public dose arising from uranium mining activities. Results of a recent report, 'Survey of Data on the Radionuclide Content of Fish in Canada' INFO 0231-1, indicated that there were very few studies of radionuclide concentrations in fish and their habitats (water and sediments) which have been conducted in Ontario or elsewhere. This project is proposed because additional data would be very useful to estimate more accurately the dose to the public resulting from consumption of fish in the Elliot Lake area, an area which accounts for all of Ontario's uranium production.

It is anticipated that the results of this study will provide reliable information to assess the dose from ingestion of fish by people in the Elliot Lake area.

Proponent	WID, RPD					
Technical Advisor/Evaluator	WID (B. Zgola), RPD (T. Tostowaryk)					
Project Manager	R. Avadhanula					
Review Panel	11					
Contractor	Laurentian University					
Principal Investigator	Dr. F. V. Clulow					
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k	

Earlier Directly-Related Contracts and Funding:

5.127.1 \$51,000

5.129.1 Decommissioning of Open Pit Mines - Literature Survey

It is proposed to conduct a literature survey of regulatory requirements for the decommissioning of all open pit mines, irrespective of the exploited mineral resource. The study would therefore include both uranium and non-uraniferous deposits.

This study is proposed because there are several open pit mines in Saskatchewan that will be decommissioned within the next year or two. These mines contain arsenic and nickel as well as uranium and it is desired to know what has been required by regulatory bodies and what has been done to effect decommissioning in the past.

It is anticipated that the results will be used to aid the AECB in assessing approaches and strategies for decommissioning proposed by licensees.

Proponent	WID
Technical Advisor/Evaluator	WID (R. Maloney)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

5.130.2 Potential Effects of Liquefaction of Uranium Tailings

It is proposed to assess the performance of tailings dams if the tailings behind them liquefy.

This study is proposed because the previous study indicated that the tailings behind the dams have the potential to liquefy if subject to earthquakes of $M \geq 6$.

It is anticipated that the results of this study will provide information on the adequacy, or lack thereof, of tailings dams to be able to contain the wastes behind them when subject to earthquakes of various ground-shaking parameters.

Proponent	WID
Technical Advisor/Evaluator	WID (S. Nguyen)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$0k	\$0k	\$25k

Earlier Directly-Related Contracts and Funding:

5.130.1 \$52,000

5.137.1 Study of Radionuclides in the Lichen-Caribou-Man Food Chain

It is proposed to study the transfer of uranium series radionuclides polonium-210 and lead-210 in the lichen-caribou-man food chain, in northern Saskatchewan and the Northwest Territories, in order to determine transfer coefficients and bio-concentration factors for these two radionuclides in this environmental pathway.

One of the areas of uncertainty regarding the impact of uranium mining is the distribution of radionuclides, in the terrestrial environment, and the subsequent movement of these radionuclides in food chains leading to man. This is of particular concern in the subarctic and arctic, where the deposition of contaminants can be widespread and the concentration in food chains significant. This possibly significant accumulation may be due to the simplicity of arctic food chains, the longevity of vital parts of the food chain and the efficiency of accumulation of contaminants by vital parts of the food chain (particularly the lichens). There has been little work on uranium series radionuclides in these climatic regions. Because of increased mining developments in Saskatchewan, and a proposed uranium mine in the Northwest Territories near Baker Lake, the question of the significance of the terrestrial pathway for uranium series radionuclides to man is current and pressing. Therefore it is proposed to study transfer and bio-concentrations of polonium-210 and lead-210 in the lichen-caribou-man pathway. Polonium is chosen because of its radiotoxicity and propensity to concentrate in soft tissue, and lead-210, to establish the ratio between the two radionuclides.

It is anticipated that the results of this study will help AECB staff to evaluate the submissions on impact to the environment and to man prepared by uranium mining licensees. Joint funding will be sought from other interested agencies such as Environment Canada and the Saskatchewan Research Council.

Proponent	RPD, WID
Technical Advisor/Evaluator	RPD (T. Tostowaryk), WID (B. Zgola)
Project Manager	R. Avadhanula
Review Panel	
Contractor	Environment Canada
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$15k	\$40k	\$0k	\$0k	\$55k

Earlier Directly-Related Contracts and Funding:

5.143.1 Radiological Impact of Uranium Mining: Northern Saskatchewan

It is proposed to: a) reassess the regional radiological impact of uranium mines currently operating, being decommissioned, or abandoned in northern Saskatchewan; and b) estimate the additional regional radiological impact of uranium mining in northern Saskatchewan that may result once all presently proposed mines are operational.

In 1986, Environment Canada and the AECB published a report entitled "An Assessment of the Radiological Impact of Uranium Mining in Northern Saskatchewan". The context of the report was the uranium mining situation in the mid-1980's, and many of the source terms and other necessary parameters used to calculate the radiological impact were taken from the literature or were estimated. The present project is proposed because the former report is limited to the consideration of operational mines at the time (Key Lake, Rabbit Lake, Cluff Lake) in northern Saskatchewan, and does not address the abandoned mines or mines undergoing decommissioning in the Lake Athabasca region. Since 1986 there have been several changes in the operational sites: mines have been mined out and new ones have been or are being developed. In addition, extensive monitoring programs and research projects have been undertaken during this period. In view of these new developments and public interest both locally and province wide, it would be of use to the AECB to reassess the regional impact of uranium mining in northern Saskatchewan and obtain an estimate of the radiological impact when all proposed mines are operating.

It is anticipated that estimates of the combined regional impact of all the facilities, proposed and operational, would be of use as a benchmark by AECB staff in assessing the mitigating measures taken by the existing facilities and those proposed by the new facilities. (Cost-sharing for this project will be sought from Environment Canada.)

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola), RPD (L. Chamney)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$20k	\$25k	\$0k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

5.144.1 Groundwater Inflow into Deep Underground Mines

It is proposed to carry out a two-phase study of the geological, hydrogeological, geochemical and geotechnical conditions at deep underground excavations located on the Canadian Shield. The study will examine these conditions in deep underground mines with special emphasis on groundwater inflow into the mines as a function of time, depth and stress conditions. The study should consider mines with underground openings at depths in excess of 500 meters, irrespective of the rock types and the ore mined.

This study is proposed because groundwater flow is recognized as the dominant factor for radionuclide release and transport from a repository to the biosphere. Due to limitations of the site investigation methods the assessment and the long-term predictions of the hydrogeological conditions in a repository will be difficult. In order to increase the confidence in these assessments, it is believed that studies of deep underground mines could be helpful, because they can provide additional perspective and support for the possible conditions that could exist in a repository.

It is anticipated that the results of this study will be used in the review of the Canadian Nuclear Fuel Waste Management Program and as a support to AECB input in the Concept Review.

Proponent	WID
Technical Advisor/Evaluator	WID (V. Poliscuk)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$75k	\$75k	\$200k

Earlier Directly-Related Contracts and Funding:

5.145.1 Standard Method for Kd Determination in Soils and Sediments

It is proposed to investigate and recommend a standard method for determining the solid/liquid partition coefficient, Kd, for use in biosphere assessment modelling.

This project is proposed because many different methods are presently used to determine this coefficient, which describes the retention of radionuclides to soils and sediments. The use of different methods, such as batch sorption methods, can lead to values differing by orders of magnitude. Further, batch sorption methods are inappropriate for unsaturated soils and could give non-conservative results leading to underprediction of the consequence of mobile radionuclides in the biosphere. Considerable expertise in these methods has been developed during the past ten years of research in this field. This project will review all the methods, point out their strengths and weaknesses, and propose and validate a "standard" technique for both soils and sediments.

It is anticipated that this project will provide AECB staff with a basis to determine whether licensees have properly evaluated the transport of radionuclides through soils and sediments in their environmental assessments.

Proponent	RPD				
Technical Advisor/Evaluator	RPD (T. Tostowaryk, M. Measures)				
Project Manager	R. Avadhanula				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$40k	\$55k	\$120k

Earlier Directly-Related Contracts and Funding:

5.146.1 Laboratory-Scale Model of a High Level Waste Repository

It is proposed to design and construct a lab-scale model (2 m x 2 m x 2 m) of a HLW repository and record its thermal-mechanical-hydrological behaviours.

AECB staff is assessing the Canadian concept of high level waste disposal. As part of this assessment, we are examining the the significance of coupling between thermal, hydrological and mechanical processes on the performance of the repository. The theory describing this coupling is called thermal consolidation. Staff has recently completed a literature review, and performed a mathematical simulation of thermal consolidation near a repository. Some preliminary conclusions can be drawn from the above work; nevertheless, to gain more confidence in the mathematical models used, a laboratory experiment should be performed to validate them.

The results of this project would be used to perform validation of AECB's mathematical models of thermal consolidation and provide data to improve these models if necessary.

Proponent	WID				
Technical Advisor/Evaluator	WID (S. Nguyen)				
Project Manager	J.L. Wallach				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

5.147.1 Assessment of the Underground Disposal of Tailings Concept

It is proposed to determine if the concept of underground disposal of tailings, produced from the milling of uranium ore, is practical, and assess the impact of removing the tailings from their current location on the surface and returning them to the mine.

Currently in the Elliot Lake area several mines are closing down and beginning the process of decommissioning. During the operational life of these mines, the tailings resulting from the milling of uranium ore have been placed on the surface and contained within a system of dams. One of the options for the decommissioning these tailings areas is to return at least some of the tailings to the underground portions of the mine. In order to assess proposals of this nature made by the licensee, there is a need to understand the implications and impacts of this decommissioning approach.

The results of this project will be used to assess the decommissioning approaches proposed by the licensee.

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

5.148.1 Reassessment of the Deep Lake Disposal of Uranium Tailings

It is proposed to re-evaluate and update a previous study on the disposal of uranium tailings in deep lakes (INFO 0070, 1982), to determine if it is a practical approach and also to assess the impacts of both removing the tailings from their current location and placing them into a deep lake.

Currently in the Elliot Lake area several mines are closing down and beginning the process of decommissioning. During the operational life of these mines, the tailings resulting from the milling of uranium ore have been placed on the surface and contained within a system of dams. One of the possible options to decommission these tailings areas is to place the tailings at the bottom of a deep lake. In order to assess proposals of this nature, made by the licensee, there is a need to understand the implications and impacts of this decommissioning method.

The results of this project will be used to assess the decommissioning approaches proposed by the licensee.

Proponent	WID					
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney)					
Project Manager	R. Avadhanula					
Review Panel						
Contractor						
Principal Investigator						
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$40k	\$0k	\$0k	\$40k	

Earlier Directly-Related Contracts and Funding:

5.149.1 Radiological Impact of Uranium Mining: Ontario

It is proposed to assess the combined regional radiological impact of operational, non-operational, and idle mines in Ontario and the contribution of each site to that impact.

Currently there is insufficient information on either the combined regional radiological impact of facilities in all stages of their life cycle, or the contribution of each facility to the overall impact.

It is anticipated that the results of this study will enable a decision to be made on whether there is a need for mitigative measures at individual sites to be identified, and will enable the assessment of the efficacy of any proposed mitigative measures in terms of the combined radiological impact.

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney), RPD (L. Chamney)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

5.143.1

6.102.1 Radiation Doses to Technologists from Radiotherapy

It is proposed to measure and compare the radiation doses received by radiotherapy technologists during performance of their duties on two different types of treatment machines (high energy accelerators and cobalt-60 machines). The aim of the project is to determine: a) the doses received by technologists working on cobalt-60 and high energy linear accelerators (≥ 10 MeV); b) the dose uniformity amongst technologists (since the dose results from the "head" of the machine which is normally above the technologist, the dose to the upper part of the body could be significantly higher than to the waist area where the TLD badge is often worn); and c) the contributions to the exposure from working inside the treatment room during the setting up of patients and from working at the control console of the machine.

This work is proposed because, in order to reduce the radiation exposure received by technologists in a radiotherapy department, it is necessary to identify the significant sources of exposure and their relative magnitudes. Also, the radiation exposures attributed to technologists may vary from machine to machine implying that there may be significant differences in exposure at the various machines.

It is expected that the proposed research will provide information on the relative exposure received by technologists working on the different types of therapy machines. From this information, the AECB may be able to infer the mechanism by which the technologists receive the major part of their personal exposures. This information is essential in order to effect changes aimed at reducing personal radiation exposures, including the re-assignment of pregnant technologists to those duties where exposure is minimized, as well as to develop protocols aimed at reducing the radiation exposure to the technologists.

Proponent	RTD
Technical Advisor/Evaluator	RTD (M. James, G.W. Brown), RPD (G. Poirier)
Project Manager	K.P. Ho
Review Panel	
Contractor	Atlantic Nuclear Services Ltd.
Principal Investigator	C. Keith Scott
Category	0

Past	90/91	91/92	92/93	Future	Total
\$27k	\$23k	\$32k	\$0k	\$0k	\$82k

Earlier Directly-Related Contracts and Funding:

6.113.1 Measurements of Radioactive Waste Disposal in Hamilton

It is proposed to measure, for the city of Hamilton, Ontario, the concentration of radioisotopes in sewer, landfill and incineration systems, due to the disposal of radioactive waste.

This project is proposed to verify with field measurements at various municipal sites, the validity of the theoretical model for calculating collective and individual doses due to the disposal of radioactive materials. This model is the result of a previous research project entitled: Determination of the Radiological Impact of Radioisotope Waste Disposal (INFO-0166).

It is anticipated that the results of this study will provide information concerning the limitations of the model discussed above. This model is to be used by AECB staff for compliance purposes.

Proponent	RTD, WID, HES				
Technical Advisor/Evaluator	RTD (R.A. Chamberlain), WID (A. Regimbald), RPD (L. Chamne;				
Project Manager	K.P. Ho				
Review Panel					
Contractor					
Principal Investigator					
Category	1				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$40k	\$0k	\$70k

Earlier Directly-Related Contracts and Funding:

6.114.3 Mortality Analysis of Persons Subjected to Fluoroscopic Examination

It is proposed to analyze the lung cancer mortality, for the period from 1950 to 1988, among nearly 100,000 Canadian tuberculosis patients (roughly equal numbers of males and females) who were exposed to multiple fluoroscopic chest examinations (x-rays) in Nova Scotia and Ontario. The dose estimates obtained from the preceding projects (6.114.1 and 6.114.2) will be used to calculate the risk of lung cancer per unit exposure to x-rays. In addition, the relative radiosensitivities of males and females for the induction of lung cancer will be examined.

To date, the lung cancer mortality among the tuberculosis patients who were exposed to multiple fluoroscopic irradiation has not been examined. Furthermore, this unique cohort (the single largest group of persons ever subjected to multiple exposures to low-LET radiation) has never been used to derive the risk of lung cancer per unit exposure to low-LET radiation. Therefore, it is prudent to use this unique data base, together with the dosimetric information obtained from the preceding project (6.114.1) to derive risk estimates for lung cancer due to exposure to low-LET radiation. Since this cohort consists of nearly equal numbers of males and females, who were exposed to x-radiation under very similar conditions and dose levels, the AECB has a unique opportunity to determine the relative radiosensitivities of males and females for the induction of lung cancer.

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to low-LET radiation. Furthermore, the study is expected to reveal the radiosensitive difference (if any) between males and females for the induction of lung cancer. Additionally, the results of the study will be used to determine the corresponding factor between the exposure unit, Working Level Month (WLM), and the dose equivalent unit, sievert (Sv). (This project is expected to be a joint study with the National Cancer Institute of Canada (NCIC) on an equal cost-sharing basis.)

Proponent	RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	02
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$30k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

6.116.1 Intercomparison of Co-60 and Cs-137 Calibrated TLDs

It is proposed to conduct a series of experiments at the Irradiation Facilities of Chalk River Laboratories to compare the exposures measured by TLDs calibrated with Cs-137 and Co-60. This series of experiments will consist of the calibration of a .035 litre ion chamber by a standard Co-60 source at the National Research Council of Canada and a standard Cs-137 source at the National Institute of Standards and Technology (U.S.A.). This ion chamber will be used to calibrate the Cs-137 and Co-60 sources in the Irradiation Facilities. The five Canadian TLD processors [AECL, Ontario Hydro (OH), Hydro-Québec (HQ), New Brunswick Electric Power Commission (NBEP), and Health and Welfare Canada (HWC)] will send their TLDs to be irradiated by these two calibrated sources. The discrepancies in measured exposures will be evaluated and studied.

Each Canadian TLD processor uses either a Co-60 or Cs-137 for calibrating its TLDs. It has been published in the open literature that a TLD calibrated with a Cs-137 source underestimates, by approximately 5%, the exposure delivered by Co-60 gamma rays. This error may seem small, but it may have significant bearings on the results of an intercomparison experiment conducted among the five TLD processors where dose-equivalents were measured and reported instead of exposures. The compounded error in such a case is more than 5%. In addition, the error at low energies, e.g. 60 keV, may be greater still. It is to the advantage of the AECB and the Canadian TLD processors to study this problem as it may be necessary to unify either the TLD calibration source or the measured and reported dosimetric quantity in order to minimize the discrepancies among the processors. This project is strongly recommended by the AECB Working Group on External Dosimetry.

The AECB will obtain valuable information for making the decision to require the measurement and reporting of unified dosimetric quantities such as $H_p(10)$ and $H_s(0.07)$, as the discrepancies observed in the intercomparison experiment may be further increased with the use of different calibration sources. (Cost sharing among AECL, OH, HQ, NBEP, H&WC and the AECB will be sought.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (G. Poirier)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$56k	\$14k	\$0k	\$70k

Earlier Directly-Related Contracts and Funding:

6.117.1 Radioisotopes Reference Manual & Data Base

It is proposed that a comprehensive but relatively non-technical data base and "pocket" reference manual be prepared covering all radioisotopes and radioisotopic compounds of commercial or health and safety interest in Canada. On one page or its equivalent would be found such information as physical characteristic: half-life, type(s) of radiation and relative abundance of each of them, radioactivity/mass relationship, degree of hazard - toxicity and radiation field (dose rate on contact and at 1 m for typical quantities), physical appearance and characteristics (solid, liquid, powder, colour, etc.), etc. The use(s) of the different compounds will also be indicated. The information could be prepared with reference to such existing documentation as the "Vade Mecum du Technicien Nucléaire" (Vol. II - Table des Caractéristiques), and product monographs from radioisotope suppliers.

One of the first questions the AECB is usually asked when an incident involving radioisotopes occurs, is "how dangerous is it?". Another concerns physical dimensioning - does the curie/TBq figure mean micrograms or tonnes? There is no handy, easily browsed source of this type of information, and it can reflect badly on the Board when answers to such apparently simple questions are not provided quickly and precisely.

The manual/data base would be used primarily by AECB staff in the Radioisotopes and Transportation Division, and the Office of Public Information. The portable manual would also be an invaluable aid to the AECB Duty Officer, Transport Canada's dangerous goods office, and emergency services such as police and fire authorities right across the country. A copy in the editorial office of all major news outlets would contribute to responsible media coverage of radioisotope incidents, as well as increase the AECB's visibility.

Proponent	OPI					
Technical Advisor/Evaluator	OPI (H. Spence), RPD (F. Horvath), RTD (R. Chamberlain)					
Project Manager	P. Duport					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$40k	\$15k	\$0k	\$55k	

Earlier Directly-Related Contracts and Funding:

6.118.1 Assessment of Tc-99m Bioassay in Medical Work Environments

It is proposed to investigate the frequency and magnitude of Tc-99m internal radioactive contamination among workers in medical environments. Identification and selection of an affordable instrument for the Tc-99m bioassay screening program will be performed. The work will be conducted in nuclear medicine hospitals and radiopharmacies.

This project is proposed because the AECB has not previously investigated, in detail, the potential intake of Tc-99m by workers in medical work environments. In addition, there is a need to identify an affordable instrument capable of detecting Tc-99m according to the requirements of "Bioassay Guideline 5 - Guideline for Tc99m Bioassay".

It is anticipated that the result of this study will provide information to AECB staff to determine the requirements for routine Tc-99m bioassay and a suitable bioassay instrumentation for workers in the nuclear medicine and radiopharmaceutical environments.

Proponent	RTD				
Technical Advisor/Evaluator	RTD (R. Brown), RPD (F. Horvath)				
Project Manager	K.P. Ho				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$50k	\$25k	\$125k

Earlier Directly-Related Contracts and Funding:

7.093.1 Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

It is proposed to fund the ongoing case-control pilot study of lung cancer deaths in uranium and non-uranium mining towns across Canada in which lung cancer mortality has been shown to be significantly elevated.

The study is proposed in order to attempt to find out to what extent various factors in the home and the workplace were responsible for excess cancer among miners and other residents of mining communities.

It is anticipated that the results of this study will be used to improve risk estimates for radiation-induced lung cancers. (This is a joint study with Statistics Canada and Health and Welfare Canada.)

Proponent	RPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)				
Technical Advisor/Evaluator	RPD (S. Ching, C. Pomroy)				
Project Manager	P. Duport				
Review Panel					
Contractor	Health & Welfare Canada				
Principal Investigator	Y. Mao				
Category	0				

Past	90/91	91/92	92/93	Future	Total
\$70k	\$0k	\$3k	\$0k	\$0k	\$73k

Earlier Directly-Related Contracts and Funding:

7.093.2 Epidemiology of Lung Cancer in a Canadian Mining Community

It is proposed to resume a case-control epidemiology study of lung cancer mortality in Canadian mining communities, initiated in Timmins, Ontario, in 1984 (project 7.093.1).

The original study was undertaken in order to identify the hazards responsible for an elevated (relative to the provincial average) incidence of lung cancer in the community. The main factor of risk being studied is long-term exposure to indoor radon daughters. The preliminary analysis of the earlier study showed a lack of correlation between 90 cases of lung cancer and domestic exposure to radon daughters. It is now proposed to study an additional 75 cases of lung cancer, and to double the number of controls for each case. The residential history of cases and controls will be traced back as far as possible.

It is expected that the results of this study will be used to reduce uncertainties in risk estimates for radon daughter-induced lung cancers, especially at low exposures. (This study will be co-funded equally by Health and Welfare Canada and the AECB.)

Proponent	RPD, HES, NHW (D. Wigle)
Technical Advisor/Evaluator	RPD (S. Ching, C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$45k	\$30k	\$120k

Earlier Directly-Related Contracts and Funding:

7.106.2 Effects of In Utero Exposure on Central Nervous System

It is proposed to fund a full-scale study of the health effects on the central nervous system (CNS) of experimental animals (mammals) following in utero exposure to ionizing radiation. Pregnant animals will be exposed to different doses and dose rates of ionizing radiation at different stages of gestation and the corresponding morphological and physical changes in the brain will be assessed quantitatively.

It is anticipated that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or fetuses may occur. Very little information is available in the literature about the effect of in utero irradiation on the development and structure of the central nervous system. A feasibility study (84.8.8) completed in 1986 recommended a full-scale study to make quantitative estimations of the risk of health defects on the CNS following in utero irradiation taking dose, dose rate, and the stage of gestation into account.

The results of the full-scale study will be used to extrapolate, from animals to humans, the risk estimates for radiation-induced developmental defects. (This is expected to be a joint study between the University of Manitoba, the University of California (Davis) and the AECB on an equal cost-sharing basis.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	01
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$9k	\$0k	\$30k	\$60k	\$210k	\$309k

Earlier Directly-Related Contracts and Funding:

84.8.8 \$22,000

7.116.1 Cancer Morbidity Follow-Up Feasibility Study

It is proposed to determine the feasibility of using computerized record linkage with national cancer incidence data available in Canada for individual medical follow-up studies by attempting to link the National Dose Registry with the Alberta Cancer Registry and to determine any association between occupational radiation exposure levels and cancer incidence. This would be of particular assistance in developing the potential future use of the Canadian Cancer Data Base.

This feasibility study is proposed because cancer data will greatly assist the AECB in determining whether any excessive cancer risks exist due to exposure to certain potentially hazardous environmental, occupational or other factors. This information will both complement and supplement mortality data available through the Canadian Mortality Data Base by providing a more sensitive measure (than mortality data alone) of the differences in risk from exposure to potentially hazardous environmental, occupational or other factors and a possible earlier detection of cancer. It will allow for earlier preventive measures to be introduced in the workplace for current as well as future employees.

It is anticipated that this study will provide the AECB with: (i) the ability to draw upon more cancer data from Canadian sources; and (ii) the opportunity to detect the occurrence of any non-fatal or rare cancers. In addition, it will assist the AECB in identifying areas of occupational, environmental, and other cancer risk. It will aid the AECB in its regulatory activity, and will also help in providing information for the assessment of exposures and occupational hygiene practices.

Proponent	RPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy, S. Ching)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$20k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

7.117.1 Hospital Record-Keeping System for Epidemiological Studies

It is proposed to conduct a feasibility study to modify hospital record-keeping systems to facilitate inexpensive case-control epidemiological studies of radiation-induced cancers.

Case-control studies of radiation-induced cancer can be conducted inexpensively using hospital records. However, the record-keeping systems in Canadian hospitals are not currently in a format that facilitates such studies.

It is anticipated that the results of the study will determine the feasibility of modifying hospital record-keeping systems to facilitate epidemiological studies. If the modification is feasible, several epidemiological studies of radiation-induced health effects can be conducted inexpensively to improve the accuracy of risk estimates. (Collaboration from NHW and provincial ministries of health will be sought.)

Proponent	RPD, HES				
Technical Advisor/Evaluator	RPD (C. Pomroy, K. Bundy)				
Project Manager	K.P. Ho				
Review Panel	02				
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$30k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

7.122.2 Expanded Cancer Incidence Linkage for the Canadian Study of Cancer following Multiple Fluoroscopies

It is proposed to expand the cohort study entitled "Computerized Linkage of National Cancer Incidence Data Base", Project 7.122.1, in order to examine further the relationship between exposure to low-LET radiation from multiple fluoroscopies and the risk of breast, lung and thyroid cancers in a cohort of 93,192 Canadian tuberculosis patients first treated in Canadian institutions between 1930 and 1952. The present proposal is to expand the cancer incidence data base to include cancer incidence data for all the years between 1970 and 1987 (in Project 7.122.1, the cancer incidence data base includes the years 1975-1983), and to relink the records from the tuberculosis cohort to the expanded data base.

The proposed expansion of the cancer incidence data base would double the number of years for which cancer incidence was available for the cohort study, and this should provide a substantial increase in the power of the subsequent statistical analysis. Using national age-specific cancer incidence rates and the breast cancer risk model derived by the BEIR V Committee, it is estimated that a total of 897 cases of breast cancer would be identified among the females in the tuberculosis study by expanding the linkage to include the years of 1970 to 1987. The expanded cancer incidence would also be of direct relevance to the computation of risk with respect to the incidence of both lung and thyroid cancers in relation to radiation exposure.

The results from this expansion will have a direct impact in improving the risk models for breast, lung, and thyroid cancers due to multiple chest fluoroscopies. In addition, the developed cancer incidence data base would be of considerable value for other on-going and planned epidemiological and cohort studies related to Canadian radiation and Canadian cancer risk studies. (This is a joint project with Statistics Canada and the National Cancer Institute of Canada, which will each contribute \$20k to the project.)

Proponent	RPD, HES, NCIC (G. Howe), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	National Cancer Institute of Canada
Principal Investigator	G. Howe
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$12k	\$12k	\$6k	\$30k

Earlier Directly-Related Contracts and Funding:

7.122.1 \$120,000

7.127.1 Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens

It is proposed to investigate the feasibility of using a flow cytometry method for measuring radiation damage in fresh (recently extracted) human lymphocytes, and to measure the damage produced by a combined exposure to radiation, delivered at doses in the occupational range, and to chemical carcinogens.

This project is proposed because currently there is uncertainty as to whether radiation and chemical insults act synergistically, independently, or whether the chemical carcinogens influence a cell's response to radiation insult. This project is intended to be an appropriate follow-on to 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", as it will provide experimental evidence of synergism or lack thereof.

It is anticipated that the findings of this study will assist AECB staff in quantifying the modifying influences of chemical carcinogens on the responses of workers to occupational radiation exposure. (This project is proposed to be funded jointly with AECL. AECL and the AECB will each contribute 50% of the cost of the project for a total of \$146K.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$48k	\$25k	\$0k	\$73k

Earlier Directly-Related Contracts and Funding:

7.128.1 The Relative Impact of Radiation-Induced Genetic Disorders

It is proposed to fund a study to determine the relative impact of different types of radiation-induced serious genetic disorders in terms of their respective loss of years of life expectancy by linking the B.C. Health Surveillance Registry Records with the Canadian Mortality Data Base.

The study is proposed because the relative impact of different types of serious genetic disorders can only be compared on a common scale, such as in terms of their respective contribution to loss of years of life expectancy. To date, no comprehensive study has been done to derive the relationship between different types of genetic disorders and their corresponding loss of years of life expectancy in the Canadian context. The data base at the B.C. Health Surveillance Registry is considered to be a leading source in North America for such a complex analysis.

It is anticipated that the results of the study will enable the AECB to compare, on a common scale, the relative impact of different types of radiation-induced genetic disorders. Initiation of this study is awaiting the review of 7.109.1. (This is proposed to be a joint study with B.C. Ministry of Health and Statistics Canada, with AECB contributing 70% of the total cost.)

Proponent	RPD, UBC (S. Sheps), Statistics Canada (M. Fair)				
Technical Advisor/Evaluator	RPD (C. Pomroy, M. Measures)				
Project Manager	V. Elaguppillai				
Review Panel					
Contractor					
Principal Investigator					
Category	3				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$45k	\$0k	\$90k

Earlier Directly-Related Contracts and Funding:

7.133.1 Bone Cancer from Radionuclide Intake

It is proposed to conduct an epidemiological study of bone cancer incidence among Canadian children and young adults exposed to radium and other bone-seeking radionuclides in drinking water and food. In the first phase of the study, radium and other bone-seeking radionuclides in typical milk and food samples, obtained from areas where well water is used for irrigation purposes, will be measured. In a subsequent phase, a detailed case-control study of bone cancer incidence, in relation to total radium and other radionuclide intake, will be investigated.

A preliminary study of bone cancer incidence among Ontario residents has identified a suggestive association between the incidence of excess bone cancer and exposure to concentrations of radium, in well water, which are higher than the provincial average. Although the level of radium in the well water used by those who contracted bone cancer was less than the National Health & Welfare-recommended maximum concentration of 1 Bq/L, the total intake of radium and other radionuclides, mainly dietary intake, should be measured to derive a relationship between the total intake of these radionuclides and the incidence of bone cancer.

The results of this study are expected to provide a quantitative relationship between excess bone cancer and the intake of total radium and other radionuclides. (This is expected to be a joint study with NHW, Ontario Ministry of Labour (OML), Ontario Ministry of the Environment and the Ontario Cancer Treatment and Research Foundation (OCTRF) at a total cost for both phases of \$900K, of which the AECB portion would be about \$120K, approximately \$60K of which is expected to be for Phase I and the balance for Phase II.)

Proponent	OCTRF, RPD, OML (M. Finkelstein)
Technical Advisor/Evaluator	RPD (F. Horvath, C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$40k	\$40k	\$120k

Earlier Directly-Related Contracts and Funding:

7.135.1 Mechanism of Radiation-Induced Mental Retardation

It is proposed to fund the ongoing laboratory experiment to study the effect of low doses of ionizing radiation on the migratory characteristics of neurons of mice and of non-human primates. Embryonic neural cells will be cultured, and exposed to different doses of ionizing radiation at different stages of neuronal development. The subsequent changes in the cellular surface structures, the number of cells present to migrate, the rates and the extent of migration of the neurons will be assessed quantitatively using a variety of monoclonal antibodies.

Recently, magnetic resonance imaging and autopsy data have established that a substantial fraction of the radiation-related cases of mental retardation seen in Hiroshima and Nagasaki bomb survivors exhibits evidence of a gross impairment of neuronal migration, seen as ectopic grey matter, largely circumventricular in distribution. It is important to understand the relationship between exposures and impaired migration and the cellular and molecular nature of this impairment in order to derive a quantitative value for the risk of mental retardation following in utero exposure to ionizing radiation.

It is anticipated that the results of this study will provide quantitative information on the mechanism of the impairment of the neuronal migratory processes. This understanding will lead to a better estimate of the risk of mental retardation due to in utero exposure to ionizing radiation. (This is a joint study with the Radiation Effects Research Foundation of Japan, Kyoto Prefectural University of Medicine (Japan), and the University of Texas Health Sciences Center in Houston. The total cost of the project is about \$280k, shared among all sponsors, with an AECB contribution of about \$80k over 3 to 4 years.)

Proponent	RPD, HES, U. of Texas (W. Schull), Kyoto University				
Technical Advisor/Evaluator	RPD (C. Pomroy)				
Project Manager	V. Elagupillai				
Review Panel	01				
Contractor	Schull, W.J.				
Principal Investigator	Prof. W.J. Schull				
Category	0				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$15k	\$15k	\$20k	\$30k	\$80k

Earlier Directly-Related Contracts and Funding:

7.137.1 Study of Childhood Cancer following Maternal X-Irradiation

It is proposed to investigate the incidence of childhood cancer among (i) those children who had abnormal delivery (such as breech presentation) or birth defects (such as Down's Syndrome), but whose mothers were not subjected to irradiation during pregnancy, and (ii) those who received in utero exposure to X-rays, both groups to be compared with suitably selected control populations.

Some controversial studies have indicated an association between maternal exposure to low doses of ionizing radiation (i.e., at levels in the neighbourhood of regulatory dose limits) and the incidence of excess childhood cancers. On the other hand, some recent studies have reported an association between abnormal pregnancy cases (such as breech presentation and Down's Syndrome) and excess childhood cancers, even in the absence of exposure to X-rays during pregnancy or delivery. It is therefore possible that the reported association between maternal irradiation and excess childhood cancer was essentially due to those cases of abnormal pregnancies and deliveries and not necessarily due to maternal irradiation on the incidence of childhood cancer.

The result of this study will improve our understanding of the qualitative association between childhood cancer and maternal irradiation and may improve the quantitative risk estimates for radiation-induced cancers.

Proponent	RPD, HES, UBC (T.W. Anderson)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	02
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$10k	\$40k	\$15k	\$65k

Earlier Directly-Related Contracts and Funding:

7.141.1 Response of Mice to Gamma Rays Delivered at Low Dose Rates

It is proposed to expose CBA/H mice to Co-60 gamma rays at low doses (1 Gy, 0.1 Gy) and low dose rates (0.004 Gy/hr, 0.02 Gy/hr, 0.1 Gy/hr, 0.5 Gy/hr) and score the subsequent incidence of myeloid leukemia in the animal population.

The primary hazards of exposure to low levels of radiation at low dose rates are generally considered to be the induction of cancer and of genetic changes. For these end points a task group has recently observed, in ICRU Report No. 40, that the appropriate quality factors for gamma rays and x-rays have been derived almost exclusively from laboratory studies on end points, such as the induction of somatic mutations in micro-organisms (*Tradescantia*). Data obtained recently suggest that doses of gamma rays up to about 1 Gy, delivered at dose rates of about 0.008 Gy/hr, have comparatively little effect on the induction rate of mammary tumours in Sprague-Dawley rats. This finding suggests that the risk due to exposure to gamma rays that are delivered in low doses may decrease to zero at low dose rates for this particular end point. If this observation were confirmed, this could lead to a reduction of the quality factor for gamma radiation delivered at low dose rates, and therefore to a re-evaluation of risk estimates for radiation-induced cancers in humans from gamma radiation. Other studies that have the induction of cancers as their end points are required to investigate the risk of gamma rays when delivered at low dose rates.

It is anticipated that this study may provide justification for reducing the quality factor below the current value of unity for gamma rays delivered in low doses and at low dose rates. This would impact on the risk estimates for radiation-induced cancer for humans from exposure to gamma rays. (This project is proposed to be cost-shared with AECL on a one-third (AECB)/two-third (AECL) basis with a total project cost estimate of \$410k.)

Proponent	RPD				
Technical Advisor/Evaluator	RPD (F. Horvath)				
Project Manager	E. Rabin				
Review Panel	06				
Contractor	Atomic Energy of Canada Ltd. - CRNL				
Principal Investigator	R.E.J. Mitchel, J.S. Jackson				
Category	0				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$33k	\$80k	\$22k	\$0k	\$135k

Earlier Directly-Related Contracts and Funding:

7.142.1 Mortality Analysis of the Fluorspar Miners from 1985-1989

It is proposed to update the mortality analysis of the fluorspar miners in St. Lawrence, Newfoundland, from 1985 to 1989. The risk of lung cancer per unit exposure to radon daughters will be recalculated using the additional mortality information and previously estimated exposures to radon daughters.

The previous analysis considered lung cancer mortality only up to 1984. Since that time, more deaths have occurred among fluorspar miners as a result of natural aging of this cohort. Since the fluorspar miners were in a unique situation, in which they were exposed to neither gamma radiation nor radioactive dust, it is important to analyze their mortality data to obtain improved risk estimates for lung cancer in a 'pure' radon daughter environment.

It is anticipated that the results of this study will further improve the risk estimates for lung cancer from exposure to radon daughters in the absence of gamma radiation and radioactive dust. (This is expected to be a joint project with the Department of National Health and Welfare and Statistics Canada.)

Proponent	RPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)				
Technical Advisor/Evaluator	RPD (C. Pomroy, S. Ching)				
Project Manager	V. Elaguppillai				
Review Panel					
Contractor					
Principal Investigator					
Category	1				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$15k	\$25k	\$10k	\$50k

Earlier Directly-Related Contracts and Funding:

7.091.1 \$170,000

7.143.1 Canadian Cancer Data Base

It is proposed to link internally the Canadian Cancer Data Base file to identify multiple records of cancer incidence for the same individual. In addition, a set of microfiche of the Canadian Cancer Data Base will be created in various format sequences to facilitate manual checking of the results of the proposed study.

This approach is proposed in order to reduce the labour required when the cancer data files are being used in the follow-up of radiation studies. Past studies have included the fluoroscopy study, the Eldorado Nuclear Limited cohort, and Atomic Energy of Canada Ltd. study.

The results of this study will help to determine whether the occurrence of cancer, where radiation was present, is significantly higher in study groups exposed to radiation. (This project will be cost-shared with Statistics Canada. Statistics Canada is to contribute \$10k and the AECB \$20k.)

Proponent	RPD, HES, Statistics Canada (M. Fair)				
Technical Advisor/Evaluator	RPD (C. Pomroy)				
Project Manager	K.P. Ho				
Review Panel					
Contractor					
Principal Investigator					
Category	3				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$0k	\$0k	\$20k

Earlier Directly-Related Contracts and Funding:

7.144.1 Development of an "Index of Harm" for Canadian Workers

It is proposed to fund a study of the procedures for integrating data from multiple sources for the purpose of developing an "index of harm" for members of the Canadian workforce. Past procedures have yielded experience with data bases in which information has been extracted from two matched files. For present purposes, the concept needs expansion to include integration of multiple sources by utilizing cross referencing and new data base techniques.

Over the past few years, for the purpose of assessing radiation risk, use has been made of: a) study cohort files; b) death records indicating endpoints (particularly cancers); c) cancer registrations; d) taxation records indicating members of cohorts still alive; and e) the social insurance number index file providing identifiers needed for follow-up. In order to develop the "index of harm" one needs also to add possible workplace accidents, genetic effects, delayed and chronic morbidity, including renal failure. The purpose of the present proposal is to prepare a coordinated plan, describing how to create a consolidated cross reference list for individuals between such files, rather than treating them mainly in a piece-meal fashion two at a time. New storage devices, new equipment (e.g., the expanding capabilities of personal computers), new data developments (e.g., the National Work Injuries and Accident Program, the Canadian Renal Failure Register) and data base packages (e.g., ORACLE or RAPID) will be examined. These new developments should be generalized and made to accommodate new data sources as they become available. Confidentiality and policies which need to be addressed in utilizing the required data source will be outlined.

It is anticipated that this study will provide AECB with: a) a brief view of recent "index of harm" literature, such as ICRP Nos. 27 and 45, along with examination of the feasibility of drawing suitable statistical data from Canadian sources; and b) recommendations for procedures for coordinating existing data collection and data base development in Canada in order to produce "index of harm" data for radiation and other industrial workers.

Proponent	RPD, HES, Statistics Canada (M. Fair)				
Technical Advisor/Evaluator	RPD (C. Pomroy)				
Project Manager	K.P. Ho				
Review Panel					
Contractor					
Principal Investigator					
Category	3				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$0k	\$0k	\$35k

Earlier Directly-Related Contracts and Funding:

7.148.1 The Combined Effects of Radiation and Chemical Substances

It is proposed to carry out an in-vitro experiment on human lymphocytes to investigate the combined effects of exposures at occupational concentrations to chemical substances, at or near threshold limit value concentrations found at nuclear facilities, and ionizing radiation delivered at doses in the occupational range.

This project is proposed because workers at Canadian nuclear facilities are exposed to chemical substances which may be potential factors in the induction of cancer among radiation workers. The interactions between exposure to radiation and chemical substances have not been accounted for in epidemiological studies. This project is proposed as a follow-on to the recently completed Project 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", which provided a 'catalogue' of chemicals found in the workplace.

It is anticipated that this project will help to assess more accurately the health risks from exposure to radiation alone as compared to those from radiation interacting with chemical substances. The nature of these interactions may be additive, antagonistic or synergistic. (AECL-CRNL is proposing to cost share this project with the AECB on a 50%-50% basis. The overall cost of this project is estimated at \$80k.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath, K. Bundy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$10k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

7.107.1 \$46,000

7.149.1 Biological Dosimetry

It is proposed to examine a spectrum of biological indicators, such as cytogenetic and immunochemical changes in blood cells (e.g. formation of micronuclei), reactive products in DNA, protein, lipid and polysaccharides, and stable biophysical changes in biological samples (e.g. hair, teeth etc.), for their suitability for measuring the extent of inadvertent or accidental exposure of individuals, and their accumulation of chronic exposure to ionizing radiation. Phase 1 of the study will consist of a detailed review and critique of existing techniques of biological dosimetry (based on currently available literature), including an assessment of their sensitivity, accuracy, reproducibility of results, and other important parameters with respect to monitoring low-level radiation exposure. Phase 2 will consist of the development and testing of a prototype biological dosimeter to establish the dose-response relationship, dose-rate effects, effects of dissolved oxygen, other environmental effects of importance in a practical biological dosimeter, convenience of use, stability, sensitivity (including the influence of the prevalence of the biological indicators in unexposed individuals), reliability, reproducibility and overall efficacy.

This study is proposed because, for accidental exposure, biological dosimetry is often all that is available, and chromosome aberration analysis does not have sufficient sensitivity or accuracy. In addition, the possibility of using these new methods for determining cumulative dose over many years is of interest.

It is anticipated that the results of this study, i.e., the development of a practical biological dosimeter, would provide AECB staff with a means of assessing the dose to licensee staff who are accidentally exposed to ionizing radiation, whether they are ARWs or not, and, in addition, possibly corroborate or refute anomalous dose data obtained from currently used personnel dosimeters. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB \$100k, AECL \$100k.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$30k	\$30k	\$100k

Earlier Directly-Related Contracts and Funding:

7.153.1 RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates

It is proposed to examine the effects of tritium beta-rays (from HTO) and Co-60 gamma-rays at "low" versus "high" dose rates, on both DNA repair-proficient and repair-deficient cultured mammalian cell lines. Two different biological end points (colony forming ability and induction of micronuclei), will be used. The results will be compared to those obtained with 200 kVp x-ray exposures at the same dose rates.

This project is proposed because tritium beta-rays account for a significant portion of the total dose from the operation of CANDU nuclear generating stations, and the estimation of dose-rate effects is assuming ever increasing importance in radiation protection programs. Values of Relative Biological Effectiveness (RBE) for tritium, as reported in the literature, range from about one to two. However, much of this variation may arise as a result of dose-rate effects, and from the use of different biological end points for determining the RBE. It is necessary to obtain experimental data that will aid in the interpretation of the RBE values reported in the literature.

It is anticipated that the findings of this study will result in an improved understanding of the relationship between dose-rate effects and different end points used for determining the RBE for exposures to tritium and gamma-rays. This study will augment and extend the earlier study, 7.120.1 Cytogenetic Measurements of the RBE of Tritium, which focused on the induction of chromosomal aberrations and translocations in mouse cells. The results of the proposed study (and 7.120.1) will assist AECB staff in evaluating the biological significance of doses from tritium and gamma-rays delivered at different dose rates.

Proponent	RPD				
Technical Advisor/Evaluator	RPD (F. Horvath, C. Pomroy)				
Project Manager	E. Rabin				
Review Panel					
Contractor	Atomic Energy of Canada Ltd. - CRL				
Principal Investigator	Dr. D.P. Morrison				
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$80k	\$40k	\$0k	\$120k

Earlier Directly-Related Contracts and Funding:

7.157.1 Paternal Exposure to Ionizing Radiation and Childhood Leukemia

It is proposed to conduct an epidemiological study of males exposed to ionizing radiation at workplaces, initially within the nuclear facilities operated by Atomic Energy of Canada Ltd. (CRNL) and Ontario Hydro (Pickering and Bruce), and the subsequent development of leukemia among their children in relation to the pre-conception radiation doses received by the fathers. At a later stage, the study may be extended to workers at other nuclear facilities and to workers in industrial applications, such as radiography.

A recent study of the Sellafield nuclear workers and the incidence of leukemia among their children has suggested a possible association between pre-conception external radiation exposure of the fathers and the subsequent development of leukemia among their children (Gardner et al., Brit. M. Journal, pp. 423-429, Feb. 1990). The lifetime doses received by the fathers of the four identified cases of childhood leukemia were in the low-dose range of 97-188 mSv (9.7-18.8 rem). Although Gardner's findings were not conclusive, his suggested association has raised world-wide concerns as to the effect of exposure to low doses of radiation on the subsequent development of genetically-induced childhood leukemia. Therefore, it is prudent for the AECB to investigate whether there exists a similar association between pre-conception radiation (internal and external) exposure of Canadian nuclear workers and the incidence of leukemia among their children.

It is anticipated that the results of the study will clarify the concerns as to whether or not there exists an association between pre-conception radiation exposure of fathers who work at Canadian nuclear facilities, and the subsequent development of leukemia among their offspring.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	01
Contractor	Ontario Cancer Treatment & Research Foundation
Principal Investigator	Dr. J.A. McLaughlin
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$76k	\$2k	\$0k	\$0k	\$78k

Earlier Directly-Related Contracts and Funding:

7.158.1 Fetal Dosimetry Workshop

It is proposed to convene a workshop on the topic of assessment of radiation doses and risks in the developing conceptus following maternal intake of radionuclides.

This workshop is proposed because more women of reproductive age are entering the nuclear industry and it is important to ensure adequate protection to the developing embryo or fetus in situations where the mother can be exposed to radionuclides which can be taken up by inhalation, ingestion, or through skin surfaces. The assessment of radiation doses and risks in the developing conceptus following a maternal intake of radionuclides requires information from a wide range of studies involving a variety of techniques. Although several laboratories have initiated research program in this area, no single program has addressed all the issues. Therefore, there is a need for a cooperative exchange of data and expertise.

It is anticipated that this workshop will allow AECB staff to gain new perspectives and information pertaining to appropriate techniques for calculating the dose to the fetus for different exposure scenarios. Development of these techniques is necessary to ensure compliance with the dose limit to an embryo or fetus. (AECL is the lead agency for convening the workshop. The operating budget for the workshop is estimated at \$20k. Funding support for the workshop is also being sought from Ontario Hydro, the Canadian Fusion Fuels Technology Project, and Health and Welfare Canada.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath, M. Légaré)
Project Manager	E. Rabin
Review Panel	
Contractor	Atomic Energy of Canada Ltd. - CRNL
Principal Investigator	E. Lamothe
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$5k	\$0k	\$0k	\$5k

Earlier Directly-Related Contracts and Funding:

7.159.1 Record Linkage Workshop - Fall 1991

It is proposed that a record linkage workshop be held in the fall of 1991. This workshop proposes to bring together persons from across Canada to present and discuss newly-developed linkage software for PCs, as well as new educational material. The application of these ideas for studies such as those relating to occupational and environmental radiation and data bases will be discussed.

This workshop is proposed because of the need to bring together scientific personnel, in different disciplines, who are contributing to rapidly-developing improvements in record linkage, related to the organization and treatment of data bases, especially those containing information on occupational and environmental radiation. Previous workshops of this type, for which the AECB has been a contributor, have drawn high praise from workers in the fields of epidemiology and data base development. The proceedings of these workshops are disseminated world-wide.

It is anticipated that the proposed workshop (and published proceedings) will be of high quality, bringing together distinguished scientists from across Canada, in disciplines in which Canada is a recognized leader. The AECB is expected to continue to derive benefit from such activities. (Support will also be sought from a number of other agencies, such as the Ontario Cancer Treatment and Research Foundation, the National Cancer Institute of Canada and the Department of National Health and Welfare.)

Proponent	Statistics Canada
Technical Advisor/Evaluator	RPD
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$5k	\$0k	\$0k	\$5k

Earlier Directly-Related Contracts and Funding:

7.160.1 Metabolism and Fetal Dosimetry of Tritium

It is proposed to conduct a series of experiments on pregnant rats to determine the uptake, distribution and retention of tritium within the conceptus of rats following the ingestion of tritium. There would be two separate sets of experiments: 1) tritiated water and 2) tritiated food. Additionally, the off-spring from these rats will be observed for leukemia incidence during their maturation.

Tritium is one of the major effluents released to the environment from CANDU reactor operations, and it is important to be able to assess realistically the committed doses received by the fetus following the ingestion of tritiated food and water by the mother. This project is proposed because in assessing the risks to the developing conceptus from exposure to tritium, many factors, such as tissue specific activity, location and metabolism of tritiated compounds, must be taken into consideration. Tritium can be incorporated into organic molecules within the cell, and into the nuclei of proliferating cells. Tritium incorporated in this way is retained in the body four times longer than that for tritiated water. Of particular importance, oocytes and latent stem cells of the hematopoietic system are long-lived tissues which may retain tritium at elevated concentrations. For the adult, the fraction of tritium incorporated into organic molecules, including DNA, is higher for tritium ingested in the form of tritiated food than for tritiated water, and results in a committed dose which is higher than that from tritiated water by a factor of about two (ICRP 56). Although little is known about the fate of tritium incorporated into the conceptus, evidence suggests that about six times as much tritium will be incorporated into the DNA of the developing conceptus in comparison to the adult.

It is anticipated that the findings from this project will enable AECB staff to evaluate more accurately the dose and subsequent risk to the fetus from uptake by the mother of tritiated water and food contaminated with tritium. The results of this study may impact on the application of the proposed amendment to the Atomic Energy Control Regulations that pertains to the dose limit to the fetus. (This is proposed as a joint project with AECL, Ontario Hydro and the Canadian Fusion Fuel Technology Project at a total cost of about \$1000k, the AECB portion of which will be about \$240k.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$80k	\$80k	\$80k	\$240k

Earlier Directly-Related Contracts and Funding:

7.161.1 A Literature Review of the Interaction between Radiation and Co-Carcinogens

It is proposed to conduct a review of the literature on the studies of combined effects of ionizing radiation and chemical carcinogens present in the work place on the induction and promotion of cancer.

Risk of radiation-induced cancer is usually confounded by the presence of chemical carcinogens present at the work place. It is not known how these agents interact in the induction and promotion of cancer. A better understanding of the extent and type of interaction between ionizing radiation and chemical carcinogens is necessary to improve the risk estimates for radiation-induced cancer. Although the information on the subject is scanty, it is important to carry out a detailed review of the literature before initiating any experimental study.

The results of this literature review will indicate to the AECB the potential of the co-carcinogenesis of radiation and chemicals, and will provide an indication of those chemicals for which additional experimental data are required to derive risk factors for co-exposures.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	V. Elagupillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$30k	\$0k	\$0k	\$30k

Earlier Directly-Related Contracts and Funding:

7.162.1 Assessment of Biases due to Measurement Errors on Risk Estimates

It is proposed to develop an appropriate statistical methodology for assessing the effect of errors in radiation dose or exposure measurements on subsequent risk estimates, and to apply this methodology to quantify the effect of measurement errors on the risk estimates for radiation-induced leukemia, breast and other solid cancers.

The errors in estimating radiation exposures used in major epidemiological studies can introduce substantial biases into the risk estimates for radiation-induced cancers. A recent AECB-sponsored study, "The Selection and Use of Control Groups in Epidemiologic Studies of Radiation-Induced Cancers", Project 7.118.1, by the National Cancer Institute of Canada has concluded that the measurement errors were likely to be the most important biases introduced into the risk estimates for radiation-induced cancers. To date, little or no attention has been given to dealing with these biases involved in risk estimates. For example, risk estimates reported in the recent BEIR IV and BEIR V reports did not take such measurement errors into account in estimating the risk of cancer due to low- and high-LET radiations. There have been a number of recent developments in the field of statistical methodology used for adjusting for measurement errors in making risk estimates, and this new information may be used to re-examine the errors associated with the risk estimates derived from Canadian and other major epidemiological studies of radiation-induced cancers.

It is anticipated that the results of this study will enable the AECB to understand the extent of the biases introduced by exposure measurement errors on currently-used risk estimates (which form the basis of the Canadian regulatory dose limits). Additionally, the study will provide the AECB with a detailed guide for addressing this problem in a number of AECB-funded, on-going and future, epidemiological studies of radiation-induced cancer and developmental disorders. (This project is expected to be a joint study with the National Cancer Institute of Canada, University of New Mexico, and the University of Southern California on an equal cost sharing basis. The total cost to the AECB is \$55k.)

Proponent	RPD, NCIC, U. of New Mexico, U. of S. California				
Technical Advisor/Evaluator	RPD (C. Pomroy)				
Project Manager	V. Elaguppillai				
Review Panel					
Contractor					
Principal Investigator					
Category	1				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$48k	\$7k	\$0k	\$55k

Earlier Directly-Related Contracts and Funding:

7.163.1 Alteration of Immune Surveillance and DNA Repair Capacity by Low Dose Rate Ionizing Radiation

It is proposed to carry out an *in vivo* study to investigate the effect of varying dose rate of gamma radiation on natural killer (NK) cell activity. The proposed study is twofold. First, groups of mice (CBA/H) will be gamma irradiated to a predetermined total dose but at decreasing dose rates. At a selected time after irradiation, NK cells from the spleens and the blood system of the irradiated mice will be isolated and the NK cell cytotoxic activity will be assessed in order to evaluate the immune surveillance capacity. In the second part, other groups of mice will be gamma irradiated at a low dose rate and to a predetermined total low dose. At a selected time after the chronic irradiation, these mice will be irradiated with a single, acute, high dose of gamma radiation. The cytotoxic activity of isolated NK cells from the acute gamma-irradiated mice will be compared with those NK cells in mice receiving a similar acute gamma radiation dose but without the low dose, chronic irradiation. The ability to perform repair of DNA damage will be monitored by radiation-induced strand breaks and base alkylation.

This project is proposed because, in order to properly estimate the risk associated with a radiation exposure, it is necessary to understand the influence of previous radiation exposure on the cellular capacity for DNA repair. Moreover, it has been known for some time that ionizing radiation depresses NK cell activity. This depression may increase the risk of radiation-induced leukemia, since experiments in rodents have shown that injection *in vitro* of cultured NK cells into irradiated mice reduce the risk of radiation-generated leukemia by about ten-fold. Because the activity of this immune surveillance system is obviously a major factor in determining the ultimate risk of radiation-initiated leukemia, it is important to understand how NK cell activity itself responds, *in vivo*, to radiation exposures delivered under conditions relevant to human exposure, that is, as split doses or at different dose rates.

It is anticipated that the results of this project will have direct bearing on the interpretation of another experiment, currently sponsored by the AECB, which will measure the influence of dose rate on the induction of myeloid leukemia produced by a predetermined low dose of gamma radiation. In addition, this project will allow a more complete understanding of the biological processes which control the probability of carcinogenesis when the same total radiation exposure is delivered in different ways. These results will impact on the standards set to regulate exposures received at low dose rate or as split doses.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Pomroy, K. Bundy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$35k	\$40k	\$18k	\$93k

Earlier Directly-Related Contracts and Funding:

7.164.1 Improved Cytometry Method

It is proposed to develop a computer-assisted, operator-driven system for dicentric chromosome analysis used in radiation accident dosimetry.

This project is proposed because chromosome analysis is, presently, a labour-intensive task. Under ideal conditions, the cytogenetics laboratory at the Bureau of Radiation and Medical Devices (BRMD), Health and Welfare Canada, analysis of one donor's cells takes 3,500 to 5,800 minutes. Should several accidental radiation over-exposures occur simultaneously, the laboratory would not be able to provide timely analyses. Dicentric chromosome analysis consists of judgemental and non-judgemental tasks. Full automation of chromosome aberration analysis is not possible with existing technology; however, it is possible to develop a computerized system, such as confirming the number of chromosomes in each cell in metaphase and recording the location of each analyzed metaphase on the microscope slide. This system would reduce the overall time for analysis by half. It may also be possible to increase the sensitivity to the analysis to a value below 100 mSv.

It is anticipated that the system developed by this project will result in the AECB obtaining better dosimetric information on radiation accident victims from BRMD, and obtaining this information more rapidly than is currently possible. (This project would be a collaborative effort by the AECB and BRMD. BRMD would provide laboratory and technical facilities, and technical direction for the performance of the work. The AECB would enter into a research agreement with BRMD for the performance of the work.)

Proponent	RPD					
Technical Advisor/Evaluator	RPD (M. Measures, C. Pomroy)					
Project Manager	E. Rabin					
Review Panel						
Contractor	Health & Welfare Canada					
Principal Investigator	Dr. J. McLean					
Category	1					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$38k	\$0k	\$0k	\$38k	

Earlier Directly-Related Contracts and Funding:

7.165.1 The Influence of Radon Daughter Exposure on Cell Mitosis Rate

It is proposed to determine the influence of exposure to Rn decay products on the rate of mitosis (cell division) of cells of the bronchial epithelium of rats. The relationship among exposure to Rn decay products, cell mitotic activity and incidence of lung cancer will be investigated. This study will be a feasibility study to determine whether the biochemical techniques referred to in the following paragraph are sufficiently well developed to proceed with a large-scale project.

A great number of laboratory animals (> 20,000) have been exposed to Rn progeny in several countries, such as France. The incidence of lung cancer per unit exposure is known and well documented. Tissues from these animals have been kept and are available for further analysis. In AECB project 4.121.2, "The Proliferative Cells Of The Human Bronchial Epithelium", it was demonstrated that the techniques exist for identifying cells that are in a specified stage of mitosis. Furthermore, one expert review panelist indicated that new currently-available techniques can identify cells that have been fixed (all metabolic activity and deterioration stopped) while at specified stages of mitosis. Since dividing cells are more prone to pre-cancerous mutations than non-dividing cells when exposed to radiation, the ratio of dividing to non-dividing cells is an index of radiosensitivity. This project is proposed because, at present, very little is known of the fundamental mechanisms of radio-carcinogenesis.

It is anticipated that the results of this study will indicate whether the biochemical techniques exist that are required for a study to determine whether alpha radiation can accelerate or stimulate mitotic activity in bronchial epithelial tissue, thereby making more cells available for pre-cancerous mutations than would otherwise be present.

Proponent	RPD					
Technical Advisor/Evaluator	RPD (F. Horvath)					
Project Manager	E. Rabin					
Review Panel						
Contractor						
Principal Investigator						
Category	3					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$25k	\$0k	\$0k	\$25k	

Earlier Directly-Related Contracts and Funding:

7.166.1 Birth Defects Due to In Utero Exposure to Ionizing Radiation

It is proposed to conduct a pilot study to determine the feasibility of a full-scale study of birth defects among children who were exposed in utero during fluoroscopic examination of their mothers during treatment for tuberculosis at several sanatoria in Nova Scotia and elsewhere in Canada during the period from 1930 to 1952. The feasibility study (involving about 45,000 women mostly in their 20s) will examine the availability of adequate information to calculate the dose to the fetus, to ascertain the different types of birth defects, including mental retardation, as a function of age and other relevant factors.

It is known that in utero exposure of pregnant women to ionizing radiation might cause birth defects among their offspring. The magnitude of the risk of radiation-induced birth defects depends on several factors, including the dose to the fetus, the rate at which the dose was delivered, and the stage of gestation and nutritional conditions at the time of radiation exposure. The currently used risk estimates for radiation-induced birth defects have a wide margin of uncertainties due to errors associated with each of these factors. Since more and more Canadian women of child-bearing age are entering the work force in the nuclear industry, it is important to improve the accuracy of the risk estimates for radiation-induced birth defects and to understand the influence of these factors on the risk estimates.

It is anticipated that the results of this pilot study will enable the AECSB to determine the feasibility of a full-scale study. If a full-scale study is found to be feasible, then the results of such a study will improve the accuracy of risk estimates for radiation-induced birth defects. (This project is expected to be a joint study with the National Cancer Institute of Canada on an equal cost sharing basis. The total cost to the AECSB is expected to be \$40k.)

Proponent	RPD, HES, National Cancer Institute of Canada				
Technical Advisor/Evaluator	RPD (C. Pomroy)				
Project Manager	V. Elaguppillai				
Review Panel					
Contractor					
Principal Investigator					
Category	1				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$40k	\$0k	\$0k	\$40k

Earlier Directly-Related Contracts and Funding:

7.167.1 Risk Estimates for Radiation-Induced Genetic Disorders

It is proposed to conduct a study to obtain improved risk estimates for radiation-induced genetic disorders. This study consists of two parts, laboratory experiments and mathematical modelling. In the first part, biological samples obtained from humans who are known to have inherited disorders, including multifactorial disorders, will be analyzed and the mutation rates for a variety of end points will be estimated. The rates will then be compared with the results obtained from animals exposed to different doses of ionizing radiation, and, subsequently, a set of probable values of relevant genetic parameters will be deduced. These parameters will be substituted into a suitably developed mathematical model, and improved risk estimates will be obtained. The mathematical model will be used to calculate the uncertainty in the risk estimates.

Currently-used risk estimates for radiation-induced genetic disorders are derived from the observations of dominant and recessive types of genetic disorders, which constitute only 1-2% of the total genetic load in the offspring of the exposed parents. Contribution to the risk estimates, from the remaining 98-99% of the disorders (multifactorial disorders) have been estimated using a number of assumptions, and some of these assumptions are now known to be associated with large uncertainties. Consequently, the overall risk estimates for radiation-induced genetic disorders may be associated with large uncertainties. The possible uncertainties in these assumptions have been discussed in the recent reports of the BEIR V and UNSCEAR 1988 Committees. Professor Sankar (a consultant to UNSCEAR) and Professors Yasuda of Japan, and Czeizel, Tusnady of Hungary, who are international experts in the field of radiation-induced genetic disorders have come up with a design to conduct a study to overcome this major uncertainty.

It is anticipated that the results on this study will improve the risk estimates for radiation-induced genetic disorders, which, in turn, will help to improve the weighting factors used to calculate the effective dose equivalent. (This is expected to be a joint study with: Leiden University, Netherlands; National Institute of Radiological Sciences, Chiba, Japan; Mathematical Academy of Sciences, Budapest, Hungary; and National Institute of Hygiene, Budapest, Hungary. Additionally, a grant of \$120k is expected from the Commission of the European Communities. The total cost of this multi-year project is expected to be \$900k, with a total contribution from the AECB of about \$80k).

Proponent	RPD, HES et al. (see list above)				
Technical Advisor/Evaluator	RPD ()				
Project Manager	V. Elagupillai				
Review Panel					
Contractor					
Principal Investigator					
Category	1				

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$25k	\$25k	\$30k	\$80k

Earlier Directly-Related Contracts and Funding:

7.168.1 Recovery of Boreal Forest Vegetation

It is proposed to study the recovery of boreal forest vegetation communities following 12 years of exposure to chronic gamma irradiation.

This project is proposed as the concluding phase of earlier work that studied changes in vegetation during 12 years of irradiation of the forest at the field-irradiator gamma site in Manitoba. The effects of radiation on forest species and other plant communities have been documented and form a good basis to describe perturbations caused by chronic low-level radiation in a natural system. Irradiation ceased in 1985, and this presents an opportunity to study recovery of the boreal forest after radiation stress. It is proposed that forest recovery be monitored to document long-term effects of gamma radiation on ecosystems. This project will be integrated with on-going international studies on effects measured near Chernobyl.

It is anticipated that this study will provide information on the long-term effects of radiation on native Canadian forests. This will allow estimation of the impact of radiation on the environment from nuclear facilities.

Proponent	RPD				
Technical Advisor/Evaluator	RPD (T. Tostowaryk, M. Measures)				
Project Manager	R. Avadhanula				
Review Panel					
Contractor					
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$40k	\$55k	\$115k

Earlier Directly-Related Contracts and Funding:

7.169.1 Ra-226 in Deciduous Teeth of Residents Living Near Mining Areas

It is proposed to determine Ra-226 levels in deciduous (milk) teeth of residents born and raised in areas near uranium mine and mill activities in Ontario in order to evaluate deposition of radionuclides in humans through environmental transfer pathways.

Ra-226 analysis of human teeth will provide good insight into the transfer of radionuclides in the environment through, mainly, food and drinking water to humans. Radium, being an analogue of calcium tends to accumulate in tissues rich in calcium. Human tooth tissues are rich in calcium and thus form potential sites for radium accumulation. Deciduous, or milk teeth, are lost in childhood and can easily be obtained for the study.

The results of this study will provide AECB staff with information on the transfer of environmental radionuclides to humans.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (R. Chatterjee)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

9.102.1 Review of AECB Crisis Management Planning

It is proposed to conduct a review of AECB operations and corporate planning and, based on the latest developments in crisis management, to determine which elements of crisis management should be included in corporate planning, and in the preparation of a crisis management manual.

Although there are AECB documents that deal with emergency response at the working level (e.g. duty officer's handbook, divisional operating procedures), there is no corporate document that deals with broader questions such as: the establishment of a crisis team; communications with the public, who handles it, and how; chain of command in the absence of someone in the management structure; interaction with other government agencies; role of the AECB Emergency Response Coordinator.

The results of this review will assist AECB staff in updating corporate plans to address crisis management, and in preparing a detailed crisis management manual.

Proponent	EXEC
Technical Advisor/Evaluator	PCS (T. Diamantstein)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$10k	\$15k	\$0k	\$0k	\$25k

Earlier Directly-Related Contracts and Funding:

9.103.2 Implementation of a New File Classification System

It is proposed to design and implement a new universal indexing scheme for the AECB records management operation that allows ready access to information by AECB staff. This activity was a recommendation of the preceding project 9.103.1, "Study of the AECB Long Range Plan for Information Management".

The subject classification in the current indexing scheme makes it difficult for users to retrieve information on a particular topic. For example, records are often distributed across several different files and if the user does not know which files then the information is effectively unavailable. The problem is analogous to a library in which the books have been catalogued under broad and ambiguous classifications using informal cataloguing rules.

As a result of this project, AECB staff and the public will be able to gain ready access to the knowledge base held in the records management system.

Proponent	IMS					
Technical Advisor/Evaluator	IMS (W. Goodwin)					
Project Manager	D.J. Martin					
Review Panel						
Contractor						
Principal Investigator						
Category	2					
Past	90/91	91/92	92/93	Future	Total	
\$0k	\$0k	\$120k	\$0k	\$0k	\$120k	

Earlier Directly-Related Contracts and Funding:

9.103.1	\$150,000
9.103.3	\$80,000

9.103.3 Implementation of New Information Management Plan

It is proposed to implement the new AECB Long Range Plan for Information Management resulting from project 9.103.1. The specific equipment, software, training, operational methods and implementation plan would be defined and described in detail and the contractor would assist AECB staff during the actual installation, training, and commissioning of the new systems.

Expert knowledge is required of the most effective means of carrying out the long range plan, from a useability and cost viewpoint. The AECB does not have sufficient in-house resources to do this.

This project would enable the AECB to implement on a timely and cost effective basis the systems and methods required to support the new Long Range Plan for Information Management.

Proponent	IMS
Technical Advisor/Evaluator	IMS (W. Goodwin)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	-
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$80k	\$0k	\$0k	\$80k

Earlier Directly-Related Contracts and Funding:

9.103.1	\$150,000
9.103.2	\$120,000

9.106.2 A Review of the UCP System

A project is proposed which would take the results of a previous contract (9.106.1) which described and documented the AECB Classification System and would propose changes to the system. The changes would ensure that the system is, in principle, fair and systematic and has no built-in biases against women or minority groups.

The AECB is in the process of reviewing the Classification System, to ensure the system conforms to government standards and regulations, particularly as it relates to salary equity.

The results of the contract would be used in the on-going evaluation and development of the AECB Personnel Classification System.

Proponent	PAB				
Technical Advisor/Evaluator	PAB (D.B. Sinden)				
Project Manager	D.J. Martin				
Review Panel					
Contractor					
Principal Investigator					
Category	3				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

9.106.1 \$16,000

9.109.3 Design of AECB Corporate Identity with Program Symbol

It is proposed that a consultant be engaged to research and design an AECB corporate identity (house style), complete with a program symbol for use on print materials, and to prepare a standards manual for design management purposes.

The basic design principles which govern the AECB's corporate identity are governed by the Federal Identity Program (FIP), a Treasury Board policy. However, in the interests of public awareness there is a requirement to highlight the AECB's unique mandate and its independence through an appropriate, customized, and uniform look in all its visual identity items, consistent with the FIP guidelines. This should incorporate a special graphic symbol to focus attention on the AECB's regulatory program. The real possibility of a name change for the agency in the near future gives a special urgency to this project, and requires that it be completed in two versions, i.e. using both titles.

The result of this support project will be used to enhance the visual image of the AECB on initial implementation, and to maintain it in future. If and when a name change is authorized, the work will provide the essential details for the changeover of all visual identity items.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$45k	\$0k	\$0k	\$45k

Earlier Directly-Related Contracts and Funding:

9.109.1	\$50,000
9.109.2	\$19,000

9.109.4 National Public Awareness Survey

It is proposed that the national public awareness survey conducted in 1988 be repeated, three years afterward, by the same research firm (Contemporary Research Centre).

The 1988 survey provided a demographic profile of the Canadian public with respect to awareness of the AECB, attitudes toward the agency, significant strengths and weaknesses, and confusion of identity with AECL. A number of communications and visibility initiatives have been taken since the national poll was conducted, and a survey is needed to evaluate their effectiveness.

The results of this study would be used in planning the strategy and tactics for corporate communications over the next three to five years.

Proponent	OPI				
Technical Advisor/Evaluator	OPI (H. Spence)				
Project Manager	A. Omar				
Review Panel					
Contractor	Contemporary Research Centre				
Principal Investigator					
Category	1				
Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$55k	\$0k	\$0k	\$55k

Earlier Directly-Related Contracts and Funding:

9.109.1	\$50,000
9.109.2	\$19,000
9.109.3	\$45,000

9.116.1 The Concept of "Environment" in a Legal Context

It is proposed to fund a workshop to examine the concept of "environment" in relation to discussions of damage due to industrial accidents and compensation. The workshop would consider whether the concept of "damage to the environment" is contained in the current legal concept of "damage to property and persons" or is a distinct entity.

The Nuclear Liability Act is intended to address, inter alia, the issue of compensation following damage to persons or property. The use of the term "environment" in such discussions appears to be used by different authors in different shades of meaning. An examination of the concept is required to determine whether the term "environment" is contained in, or equivalent to, "property and persons".

The results of the workshop would be used in deliberations relating to international conventions which address the liability issue and in national discussions on the protection of Canadians.

Proponent	Secretariat
Technical Advisor/Evaluator	Secretariat (J. McManus)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$20k	\$0k	\$0k	\$20k

Earlier Directly-Related Contracts and Funding:

9.119.2 Technical Training Overview Course

It is proposed to fund the development of teaching materials for the Technical Overview Course to be given for new technical staff at the AECB.

The recent expansion of the AECB requires the training of new staff. A course curriculum has been developed by the Technical Training Advisory Group (TTAG).

The results of the contract would be used in giving the Technical Overview Course.

Proponent	Technical Training Advisory Group
Technical Advisor/Evaluator	PERS (B. Richard)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$50k	\$100k	\$0k	\$0k	\$150k

Earlier Directly-Related Contracts and Funding:

9.119.1 \$50,000

9.120.2 Preparation of the RIAS for New Dose Limits - Phase 2

In order to incorporate new dose limits into the AEC regulations, a Regulatory Impact Analysis Statement (RIAS) will be required. In view of the publicity surrounding the ICRP recommendations on which the new limits will be based, it is essential to be as far advanced as possible in developing the RIAS at the time that the ICRP recommendations are published, which is expected to be in the first half of 1991, so that there is minimal delay in the process to amend the AEC Regulations.

Because of this urgency, it is proposed to conduct the RIAS preparation in discrete steps. This project includes the following steps: a) distributing the questionnaire (from 9.120.1) and providing assistance with its completion; and b) analyzing the questionnaire returns and assessing their "reasonableness". The new limits will include a reduced public limit, from 5 mSv/y to 1 mSv/y. The impact of such a reduction was included in the RIAS questionnaire for the General Amendments, and so that should not need repetition, although responders should be asked to review their previous comments.

The preparation of a RIAS is an essential part of the regulatory process. The format of the RIAS is prescribed by the Office of Privatization and Regulatory Affairs and strict adherence to their requirements will enable the Board to assess the impact of the proposed new limits and take the results of this assessment into account in considering their adoption.

Proponent	Executive Committee
Technical Advisor/Evaluator	Executive Committee, RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	Price Waterhouse Management Consultants
Principal Investigator	Oliver Kent
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$20k	\$80k	\$0k	\$0k	\$100k

Earlier Directly-Related Contracts and Funding:

9.120.1 \$22,000

9.121.1 Nuclear Terminology (English/French) Data Bank

It is proposed that an English-French terminology data bank be assembled covering terms, idioms, and expressions found in the Canadian nuclear regulatory environment. This would involve collecting material from glossaries and partial terminology listings that exist (at the AECB and elsewhere), original research on terms, and a thorough review of the final compilation for completeness, accuracy and consistency. It is hoped that this work could be carried out as a joint venture with other interested organizations (Secretary of State Translation Bureau, Hydro-Québec, AECL, etc.)

Both freelance and staff translators working on AECB material have limited terminological resources at their disposal when it comes to the jargon of such activities as reactor regulation and radiation protection. Other AECB staff creating original text in French, particularly those based on English references, are similarly handicapped. There is a consequent tendency to create mini-lexicons for personal use, with resulting problems in corporate standardization (uniformity) and accessibility. Where the AECB interfaces with francophone licensees, e.g. operator certification, lack of a standard lexicon can present difficulties.

The data bank would be used by all AECB personnel involved in producing or reviewing French text. Access to it could be maximized so that many others could profit from its use.

Proponent	OPI, ACS
Technical Advisor/Evaluator	OPI (G. Plante), ACS (P. Goyette)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	90/91	91/92	92/93	Future	Total
\$0k	\$0k	\$50k	\$0k	\$0k	\$50k

Earlier Directly-Related Contracts and Funding:

11.106.1 Preparation and Distribution of MAGNEC Minutes

Minutes of MAGNEC (Multi-Agency Group for Neotectonics in Eastern Canada) meetings are to be recorded and distributed to all MAGNEC members.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Grier, M.
Principal Investigator	
Category	0

Past	90/91	91/92	92/93	Future	Total
\$0k	\$2k	\$3k	\$0k	\$0k	\$5k

Earlier Directly-Related Contracts and Funding:

**FUNDING (\$K) OF
AECB REGULATORY RESEARCH AND SUPPORT PROGRAM
BY MISSION OBJECT**

(FY 1991/92 ALLOCATION: \$3,800K)

MISSION OBJECT	FY 1991/92 ALLOCATION (\$K)		
	CATEGORIES 0, 1, 2	CATEGORY 3	TOTAL
2. Nuclear Reactors	\$1,840	\$1,505	\$3,345
3. Other Fuel Cycle Facilities, General	\$544	\$392	\$936
4. Uranium Mines and Mills	\$375	\$95	\$470
5. Waste Management	\$320	\$105	\$425
6. Non Fuel Cycle Applications	\$162	\$96	\$258
7. Health Physics	\$493	\$503	\$996
8. Transportation	-	-	-
9. Regulations & Regulatory Process Development	\$420	\$195	\$615
11. Special Services	\$3	-	\$3
Total	\$4,157	\$2,891	\$7,048

LIST OF REVIEW PANELS FOR REGULATORY RESEARCH & SUPPORT PROGRAM PROJECTS

1. RADIATION-INDUCED DEVELOPMENTAL DEFECTS

Project Manager: V. Elaguppillai

In Progress:

Effects on Central Nervous System from
In Utero Exposure (7.106.2)

Mechanism of Radiation-Induced Mental
Retardation (7.135.1)

Paternal Exposure to Ionizing Radiation and
Childhood Leukemia (7.157.1)

2. EPIDEMIOLOGY

Project Manager: V. Elaguppillai

In Progress:

Study of Childhood Cancer following
Maternal X-Irradiation (7.137.1)

Planned:

Mortality Analysis of Beaverlodge Uranium
Miners from (4.118.2)

Project Manager: E. Rabin

Planned:

Mortality Analysis of Persons Subjected to
Fluoroscopic Examination (6.114.3)

Project Manager: K.P. Ho

Planned:

Hospital Record-Keeping System for
Epidemiological Studies (7.117.1)

3. INHALATION STUDIES

Project Manager: P.J. Duport

In Progress:

Study of the Health Effects of Inhaled
Uranium Ore Dust (4.101.1)

4. DOSIMETRIC MODELS

Project Manager: P.J. Duport

In Progress:

Evaluation of Data and Models on Uranium Metabolism - Europe (3.111.1)

Project Manager: K.P. Ho

Planned:

Absorbed Fraction of Ingested Uranium in Humans (3.103.1)

5. LUNG SOLUBILITY STUDIES

Project Manager: K.P. Ho

In Progress:

Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities (4.103.2)

Project Manager: P.J. Duport

In Progress:

Influence of Macrophages on Dissolution of Uranium Compounds (3.123.1)

6. RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)

Project Manager: E. Rabin

In Progress:

RBE of Gamma Rays Delivered at Low Dose Rates (7.141.1)

7. BRONCHIAL EPITHELIUM

No 1991/92 Panel

8. RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS

No 1991/92 Panel

9. URANIUM TOXICITY No 1991/92 Panel
10. HYDROGEOLOGY No 1991/92 Panel
11. ENVIRONMENTAL PATHWAYS
Project Manager: R. Avadhanula Planned:
Radionuclide Concentrations in Fish:
Phase 2 (Detailed Analyses) (5.127.2)
12. SOFTWARE RELIABILITY No 1991/92 Panel
13. GEOCHEMISTRY No 1991/92 Panel
14. SEVERE ACCIDENTS
Project Manager: A. Omar In Progress:
Consequences of Severe Accidents in
Canadian Power Reactors (2.157.1)
Planned:
Detailed Analysis of Severe Accident
Consequences (2.157.2)
15. NPP AGING
Project Manager: A. Omar Planned:
Ballooning of CANDU Pressure Tubes -
Experimental Studies (2.184.3)

16. DEEP GEOLOGICAL DISPOSAL

Project Manager: J.L. Wallach

Planned:Demonstration of the Feasibility of Directly
Dating Quartz (3.101.2)**17. EXPOSURE EVALUATION**

No 1991/92 Panel

**18. EXPOSURES OF
NON-MONITORED PERSONNEL**

No 1991/92 Panel

19. FOETAL DOSIMETRY

No 1991/92 Panel

20. CONTACT DOSIMETRY

No 1991/92 Panel

**21. NPP EQUIPMENT
QUALIFICATION (Environmental
and Dynamic)**

No 1991/92 Panel

22. SEISMIC HAZARD

Project Manager: J.L. Wallach

In Progress:Seismic Monitoring East and North of
Toronto (2.217.1)Planned:Marine Geophysics in Lake Ontario
(2.222.1)

**STANDARD ABBREVIATIONS
AECB ORGANIZATIONAL UNITS**

**SIGLES COURANTS DES UNITÉS
ORGANISATIONNELLES DE LA CCEA**

Office of the President	OPR	Bureau du Président
Advisory Committee on Radiation Protection	ACRP	Comité consultatif de la radioprotection
Advisory Committee on Nuclear Safety	ACNS	Comité consultatif de la sûreté nucléaire
Secretariat	SEC	Secrétariat
Secretary to the Board	SEB	Secrétaire de la Commission
Office of Public Information	OPI	Bureau d'information publique
Planning and Coordination Section	PCS	Section de la planification et de la coordination
Advisory Committee Secretariat	AC	Secrétariat des groupes consultatifs
Legal Services Unit	LSU	Services juridiques
Official Languages Advisor	CLO	Conseiller en langues officielles
Medical Liaison Officer	MLO	Agent de liaison médical
Directorate of Reactor Regulation	DRR	Direction générale de la réglementation des réacteurs
Power Reactor Division A	PRDA	Division A des réacteurs nucléaires
Power Reactor Division B	PRDB	Division B des réacteurs nucléaires
Operator Certification Division	OCD	Division de l'accréditation des opérateurs

Studies and Codification Division	SCD	Division des études et de la codification
Directorate of Fuel Cycle and Materials Regulation	DFC	Direction générale de la réglementation du cycle du combustible et des matières nucléaires
Radioisotopes and Transportation Division	RTD	Division des radio-isotopes et des transports
Compliance Services and Laboratories Division	CSLD	Division des contrôles et des laboratoires
Uranium Facilities Division	UFD	Division des installations d'uranium
Wastes and Impacts Division	WMD	Division des déchets et des incidences
Directorate of Assessment and Analysis	DAA	Direction générale de l'évaluation et de l'analyse
Safety Evaluation Division	SED	Division de l'évaluation de la sûreté
Components and Quality Assurance Division	CQAD	Division des composants et de l'assurance-qualité
Radiation Protection Division	RPD	Division de la radioprotection
Directorate of Research and Safeguards	DRS	Direction générale de la recherche et des garanties
Safeguards and Security Division	SSD	Division des garanties et de la sécurité
Research and Support Division A	RSDA	Division A de la recherche et du soutien
Research and Support Division B	RSDB	Division B de la recherche et du soutien
Directorate of Administration	PAB	Direction générale de l'administration

Administration Division	ADD	Division de l'administration
Finance Section	FIS	Section des finances
Personnel Section	PES	Section du personnel
Information Management Section	IMS	Section du traitement de l'information

List of 1991/92 Research Projects

I.D. Number	Project Title	Category
Mission Object 02		
2.101.1	Instrument Behaviour under Off-Normal Conditions	3
2.102.1	Design, Analysis and Testing Tools for Real-Time Software	3
2.105.2	Crack Propagation in Tough Ductile Materials - Carbon Steel	3
2.111.1	International Piping Integrity Research Group	0
2.111.2	International Piping Integrity Research Group - 2	2
2.117.3	International Standards for Safety Critical Software	0
2.118.1	Behaviour of the Calandria Structure under Severe Conditions	3
2.126.2	Critical Channel Power Uncertainty Measurement	1
2.127.5	Statistically Valid Random Testing for Real-Time Software	0
2.130.2	Self-Testing of Programmable Controllers and Microcomputers	1
2.148.2	Molten Fuel/Moderator Interaction - Feasibility of Large Scale Tests	3
2.152.4	Five-Channel-per-Pass CATHENA Code for Darlington NGS	1
2.153.1	Computer Codes for Examining Circulation within Containment	3
2.155.1	Maintenance: Means and Methods	1
2.157.1	Consequences of Severe Accidents in Canadian Power Reactors	0
2.157.2	Detailed Analysis of Severe Accident Consequences	3
2.170.1	Reliability of Electrical Motors under Accident Conditions	3
2.174.2	Hydrogen Absorption-Desorption at Metal Surfaces - Phase 2	1
2.175.1	Pump Cavitation and Piping Vibration (I)	3
2.177.2	Fuel Channel Refilling - Phase II	0
2.179.1	Performance of Steam Generator Emergency Water Injection	1
2.181.2	A Computer Program for Assisting Emergency Response Function	3
2.184.3	Ballooning of CANDU Pressure Tubes - Experimental Studies	1
2.187.2	Operational Readiness of Filtered Air Discharge Systems - Phase 2	1
2.190.1	Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments	3
2.192.1	Effect of Sheath Strain on Critical Heat Flux	0
2.193.1	Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants	3
2.197.1	Fission Product Release at SLOWPOKE Reactors	0
2.198.1	Containment Performance under Severe Accidents	3
2.199.1	The Prevention, Mitigation and Accommodation of Water Hammer	1
2.200.1	A Safety Course for Pressure-Tube Type Reactors	1
2.202.1	Severe Accident Source Term	3
2.203.1	Intermediate and Full Scale Tests on Hydrogen Burn Phenomena	1

I.D. Number	Project Title	Category
2.204.1	Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings	1
2.205.1	Training Requirements for Authorized Operating Personnel	1
2.206.1	Methodology for Assessment of Training Programs	1
2.208.1	Review of Darlington Probabilistic Safety Evaluation Events Involving Operating Action	3
2.210.1	Participation in the USNRC Severe Accident Research Program	3
2.211.1	Tritium Surface Contact Dosimetry	0
2.213.1	Review of Human Factors Guidelines	1
2.216.1	Validation of Positive Void Effect	0
2.217.1	Seismic Monitoring East and North of Toronto	0
2.219.2	Validation Methods for Probabilistic Safety Assessments - Phase 2	1
2.220.1	Impact of Expert Systems	3
2.221.1	Evaluation of Boiler Chemical Cleaning Techniques	0
2.222.1	Marine Geophysics in Lake Ontario	1
2.223.1	Use of VDM in Formal Specifications	0
2.224.1	Emissivity of Zirconium Alloy Surfaces	3
2.225.1	Estimates of Fission Product Grain-Boundary Release	3
2.226.1	Graphical Post Processor for Scientific Computer Codes	3
2.227.1	Failure Rate of Piping in Hydrogen Sulfide Systems	1
2.228.1	Acceptance Limit for Steam Generator Tube Loss of Wall Thickness	1
2.229.1	Criteria and Tools for Scientific Software Quality Measurements	1
2.230.1	Testing for Software Reliability in Computer Systems	3
2.231.1	Functional Block Languages and Design Methods	3
2.232.1	Object Oriented Languages and Design Methods	3
2.233.1	A Cumulative Knowledge Base for Software Testing	3
2.234.1	Review of "Sub-Tier" Software Standards	0
2.234.2	Evaluation of Tools and Methods for the Development of Safety Critical Software	1
2.234.3	Review of Prototype Application of Software Standards	1
2.234.4	Review of Trip Computer System Specifications	2
2.234.5	Review of Trip Computer Redesign	2
2.234.6	Review of Trip Computer Testing	2
2.235.1	Processes in Radioactivity Removal	3
2.236.1	Diagnostic Skills and Mental Model Development	1
2.237.1	Assessment of Psychological Capacities Requirements	1
2.238.1	Review of Computer Codes MODTURC and PHOENICS	1
2.239.1	Installation and Training in the Use of Aerosol Computer Codes	3
2.240.1	Geophysical Data Analysis - Darlington & Pickering Region	1
2.241.2	Technical Review of the CANDU-3 PSA (Phase 2)	1

I.D. Number	Project Title	Category
Mission Object 03		
3.101.2	Demonstration of the Feasibility of Directly Dating Quartz (2)	3
3.103.1	Absorbed Fraction of Ingested Uranium in Humans	1
3.111.1	Evaluation of Data and Models on Uranium Metabolism - Europe	0
3.111.2	Evaluation of Data and Models on Uranium Metabolism - North America	0
3.123.1	Influence of Macrophages on Dissolution of Uranium Compounds	0
3.125.1	Study of Chemical Toxicity of Uranium Hexafluoride	3
3.134.1	RBE from a Microdosimetric Approach	3
3.144.3	Paleoseismicity in the Saguenay Region	3
3.146.1	Canadian Atmospheric Stability Indicators	3
3.150.2	Effects of Radiation on Species Other than Man: Aquatic Organisms	3
3.151.1	Canadian Data Base for Radionuclide Transfer in the Environment	1
3.152.1	Production of Public Information Material on the Effects of Radiation	0
3.154.1	Optimization of Doses between Atomic Radiation Workers and the Public	3
3.155.1	Validation of Environmental Pathways Analysis Models	0
3.156.2	Geology at an Apparently Seismically Active Intersection	3
3.157.1	A Field Evaluation of Convolute Laminations	3
3.160.1	Radionuclide Analysis in Dissolution Tests	0
3.161.1	Radiation Facts Booklet	1
3.162.1	Monitoring Uranium Emissions from a UF ₆ Plant Stack	1
3.163.1	The Origin of Conical Hills, Charlevoix Seismic Zone	3
3.164.1	Carbon-14 in Lakes: Appropriate Risk Assessment	3
3.165.1	HTO and C-14 Cycling following Chernobyl	3
3.166.1	Historical Seismicity Study of Prince Edward County Area, Ontario	3
3.167.1	Effects of Microdistribution of Tritium on Dose Calculations	1
3.168.1	Possible Toxic Effects of Heavy Water Plant Effluents on Livestock	1
3.169.1	Computer Software Quality Assurance	1
Mission Object 04		
4.101.1	Study of the Health Effects of Inhaled Uranium Ore Dust	0
4.103.2	Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities	0
4.106.4	Ontario Miners Mortality Study - Annual Update	1
4.112.1	Electrical Charge of Radioactive Aerosols in Uranium Mines	3
4.117.1	Evaluation of Long-Lived Dust Exposures from Silica Samples	3
4.118.2	Mortality Analysis of Beaverlodge Uranium Miners from 1981-1989	0
4.125.1	Exposure-Rate Effectiveness for the Induction of Lung Cancer	1
4.126.1	Computerized Mortality Search Procedures	3
4.130.1	Evaluation of Radon Daughter Exposures of Port Radium Miners	1

I.D. Number	Project Title	Category
4.130.2	Mortality Analysis of Port Radium Uranium Miners (1950-1989)	1
Mission Object 05		
5.127.2	Radionuclide Concentrations in Fish: Phase 2 (Detailed Analyses)	1
5.129.1	Decommissioning of Open Pit Mines - Literature Survey	3
5.130.2	Potential Effects of Liquefaction of Uranium Tailings	1
5.137.1	Study of Radionuclides in the Lichen-Caribou-Man Food Chain	0
5.143.1	Radiological Impact of Uranium Mining: Northern Saskatchewan	0
5.144.1	Groundwater Inflow into Deep Underground Mines	1
5.145.1	Standard Method for Kd Determination in Soils and Sediments	3
5.146.1	Laboratory-Scale Model of a High Level Waste Repository	1
5.147.1	Assessment of the Underground Disposal of Tailings Concept	3
5.148.1	Reassessment of the Deep Lake Disposal of Uranium Tailings	1
5.149.1	Radiological Impact of Uranium Mining: Ontario	1
Mission Object 06		
6.102.1	Radiation Doses to Technologists from Radiotherapy	0
6.113.1	Measurements of Radioactive Waste Disposal in Hamilton	1
6.114.3	Mortality Analysis of Persons Subjected to Fluoroscopic Examination	1
6.116.1	Intercomparison of Co-60 and Cs-137 Calibrated TLDs	3
6.117.1	Radioisotopes Reference Manual & Data Base	3
6.118.1	Assessment of Tc-99m Bioassay in Medical Work Environments	1
Mission Object 07		
7.093.1	Epidemiology of Lung Cancer Mortality in Canadian Mining Communities	0
7.093.2	Epidemiology of Lung Cancer in a Canadian Mining Community	2
7.106.2	Effects of In Utero Exposure on Central Nervous System	1
7.116.1	Cancer Morbidity Follow-Up Feasibility Study	3
7.117.1	Hospital Record-Keeping System for Epidemiological Studies	1
7.122.2	Expanded Cancer Incidence Linkage for the Canadian Study of Cancer following Multiple Fluoroscopies	1
7.127.1	Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens	3
7.128.1	The Relative Impact of Radiation-Induced Genetic Disorders	3
7.133.1	Bone Cancer from Radionuclide Intake	3
7.135.1	Mechanism of Radiation-Induced Mental Retardation	0
7.137.1	Study of Childhood Cancer following Maternal X-Irradiation	0
7.141.1	Response of Mice to Gamma Rays Delivered at Low Dose Rates	0
7.142.1	Mortality Analysis of the Fluorspar Miners from 1985-1989	1
7.143.1	Canadian Cancer Data Base	3
7.144.1	Development of an "Index of Harm" for Canadian Workers	3

I.D. Number	Project Title	Category
7.148.1	The Combined Effects of Radiation and Chemical Substances	3
7.149.1	Biological Dosimetry	3
7.153.1	RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates	1
7.157.1	Paternal Exposure to Ionizing Radiation and Childhood Leukemia	0
7.158.1	Fetal Dosimetry Workshop	1
7.159.1	Record Linkage Workshop - Fall 1991	1
7.160.1	Metabolism and Fetal Dosimetry of Tritium	3
7.161.1	A Literature Review of the Interaction between Radiation and Co-Carcinogens	3
7.162.1	Assessment of Biases due to Measurement Errors on Risk Estimates	1
7.163.1	Alteration of Immune Surveillance and DNA Repair Capacity by Low Dose Rate Ionizing Radiation	3
7.164.1	Improved Cytometry Method	1
7.165.1	The Influence of Radon Daughter Exposure on Cell Mitosis Rate	3
7.166.1	Birth Defects Due to In Utero Exposure to Ionizing Radiation	1
7.167.1	Risk Estimates for Radiation-Induced Genetic Disorders	1
7.168.1	Recovery of Boreal Forest Vegetation	1
7.169.1	Ra-226 in Deciduous Teeth of Residents Living Near Mining Areas	3
On Object 09		
9.102.1	Review of AECB Crisis Management Planning	0
9.103.2	Implementation of a New File Classification System	2
9.103.3	Implementation of New Information Management Plan	3
9.106.2	A Review of the UCP System	3
9.109.3	Design of AECB Corporate Identity with Program Symbol	3
9.109.4	National Public Awareness Survey	1
9.116.1	The Concept of "Environment" in a Legal Context	3
9.119.2	Technical Training Overview Course	0
9.120.2	Preparation of the RIAS for New Dose Limits - Phase 2	0
9.121.1	Nuclear Terminology (English/French) Data Bank	1
Mission Object 11		
11.106.1	Preparation and Distribution of MAGNEC Minutes	0